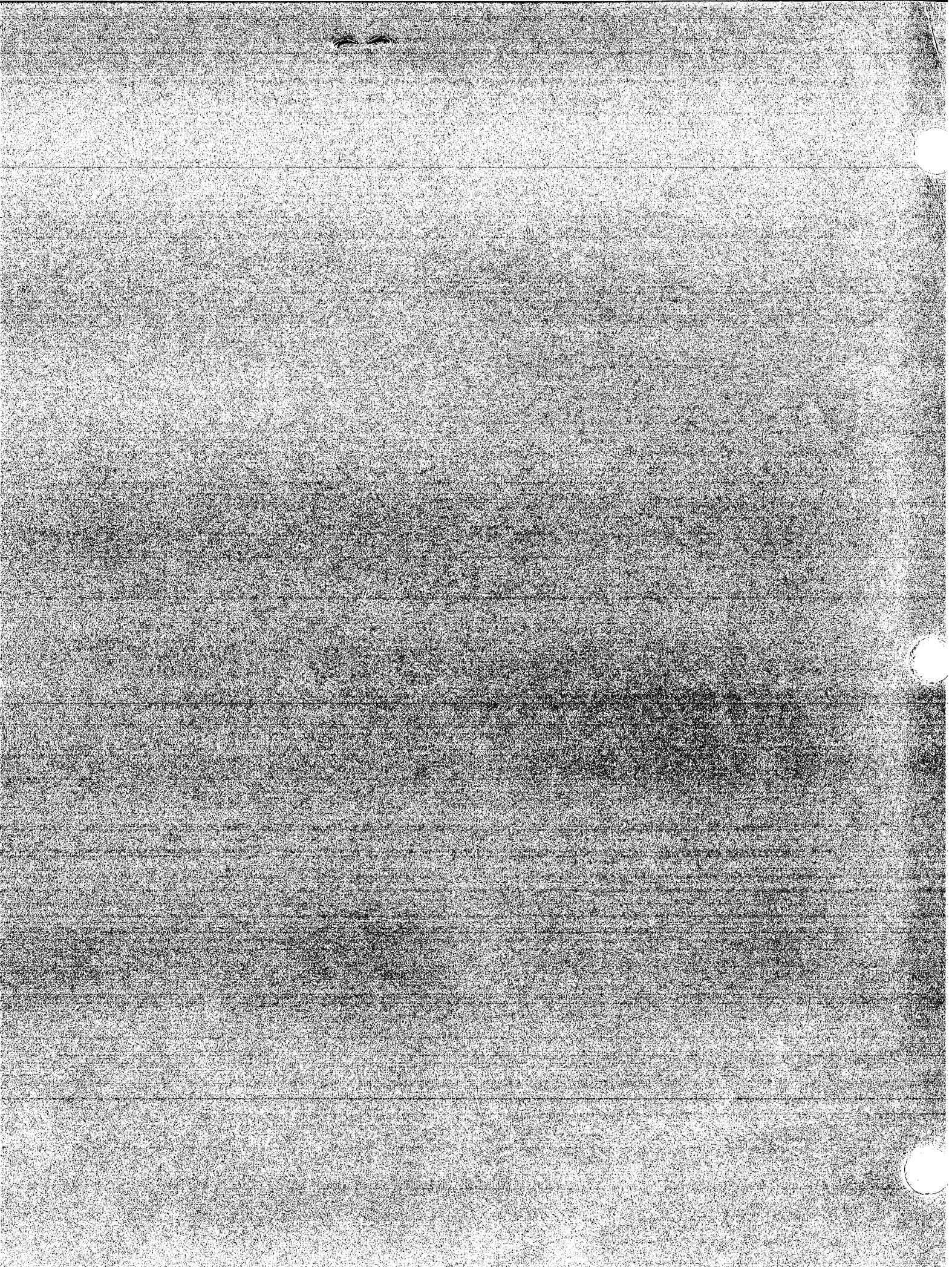


(NH8-5300.4(3I)) REQUIREMENTS FOR
PRINTED WIRING BOARDS (NASA) 78 p

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CHANGE 1
NHB 5300.4(3I)
Effective Date June 26, 1990

REQUIREMENTS FOR
PRINTED WIRING BOARDS

1. This Change 1 reflects the following:

<u>PAGE</u>	<u>CHANGE</u>
2	Paragraph 103-3, Page 2 - adds additional qualification requirements as an additional sentence to the paragraph.
32	Table 5-2, Page 32 - corrects dimensional error in solder coat reference.
49	Paragraph 625, Page 49 - changes "°C" to "°F" correcting "Centigrade" to "Fahrenheit" in the fifth line of the paragraph.

2. Remove pages 2, 32, and 49 and insert the attached pages.
3. Record receipt of this change on the Change Check List which should be filed in front of the Preface, page i.
4. This cover sheet may be retained.

DISTRIBUTION
SDL 1 (SIQ)

CHANGES CHECK LIST

This check list is provided for recording receipt of changes , date of change, name of poster and date of posting .

CHANGE		POSTING		CHANGE		POSTING	
No.	Date	Initials	Date	No.	Date	Initials	Date
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
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8				23			
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10				25			
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12				27			
13				28			
14				29			
15				30			

PREFACE

Date: May 1984

In order to maintain the high standards of the NASA printed wiring programs, this publication:

- Prescribes NASA's requirements for assuring reliable rigid printed wiring boards.

- Describes and incorporates basic considerations necessary to assure reliable rigid printed wiring boards.

- Establishes the supplier's responsibility to train and certify personnel.

- Provides for supplier documentation of the fabrication and inspection procedures to be used for NASA work, including supplier innovations and changes in technology.

- Provides visual workmanship standards to aid those responsible for determining quality conformance to the established requirements.

NASA Installations shall:

- Invoke the provisions of this publication in procurements involving rigid printed wiring boards for aircraft, spacecraft, launch vehicles, mission essential support equipment, and elements thereof as appropriate to design or project requirements. Appendix A contains definitions for terminology used in this publication. Appendix B contains a procedure for the preparation of samples for metallographic examination. Appendix C contains referenced Institute of Printed Circuits (IPC) test methods for solder mask evaluation.

- Amend, when timely and within cost constraints, existing contracts to invoke the requirements of this publication.

- Utilize the provisions of this publication for in-house printed wiring fabrication operations and, as necessary, for training and certifying of in-house personnel.

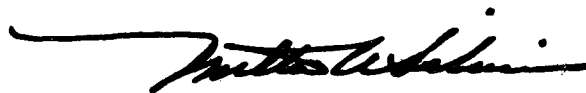
- Assure that NASA contractors invoke the provisions of this publication in their subcontracts and purchase orders.

- Furnish copies of this publication, in the quantities required, to NASA contractors, subcontractors, and subtier suppliers.

Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA installation or its designated representative.

This publication shall not be rewritten or reissued in any other form.

Copies of this publication are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

A handwritten signature in black ink, appearing to read "Milton A. Silveira", with a long horizontal flourish extending to the left.

Milton A. Silveira
Chief Engineer

DISTRIBUTION:

SDL 1 (SIQ)

ORGANIZATION OF THE R&QA MANUAL

OVERALL COVERAGE

The Reliability and Quality Assurance Manual - referred to as the "R&QA Manual" - is the overall generic title which identifies all NASA R&QA management publications published under the basic R&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete R&QA Manual) are published as individual R&QA publications.

The following list shows the grouping and R&QA publications:

Title Volume 1 - General Provisions

Title	Number
Reliability Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1A) (April 1970)
Quality Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1B) (April 1969)
Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components and Services	NHB 5300.4(1C) (July 1971)
Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	NHB 5300.4(1D-2) (October 1979)

Volume 2 - Government Agency Provisions

Management of Government Quality Assurance Functions for Supplier Operations	NHB 5330.7 (April 1966)
Quality Assurance Provisions for Government Agencies	NHB 5300.4(2B) (November 1971)

Volume 3 - Standards

Requirements for Soldered Electrical Connections	NHB 5300.4(3A-1) (December 1976)
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Qualified Products Lists Requirements for Microcircuits	NHB 5300.4(3F) (June 1972)
Requirements for Interconnecting Cables, Harnesses, and Wiring	NHB 5300.4(3G) (soon to be released)
Requirements for Crimping and Wire Wrap	NHB 5300.4(3H) (May 1984)
Requirements for Printed Wiring Boards	NHB 5300.4(3I) (May 1984)
Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies	NHB 5300.4(3J) (soon to be released)

DOCUMENT REFERENCING

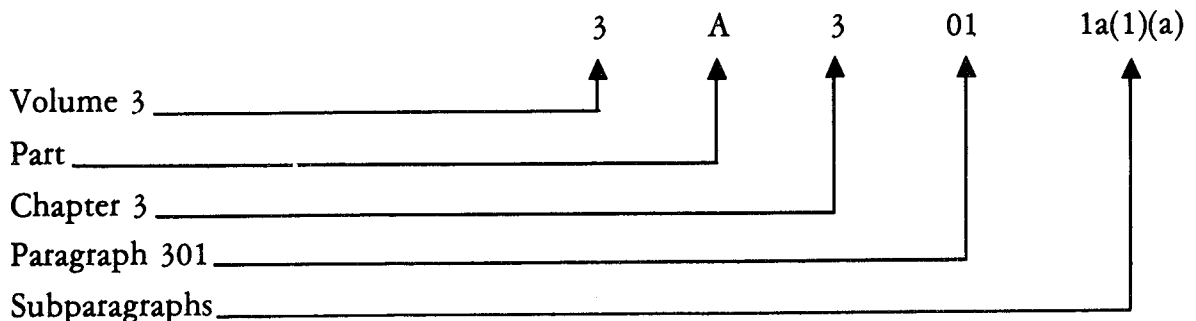
Each R&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): This number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number, such as NHB 5300.4(3A-1).

In referencing or requesting any R&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. **Within the R&QA Manual.** The following shows the paragraph numbering system applicable to all R&QA publications.



This system provides for referencing any R&QA publication requirement (paragraph) in any other R&QA publication without the need for identifying the NHB number, title, the volume number, or part. However, when referencing a complete Part within another R&QA publication, the specific NHB number must be used.

2. **In Other NASA Documents.** When it is necessary to reference an R&QA publication requirement (paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4(3A-1), paragraph 3A301-1a(1)(a)," or "paragraph 3A301-2b of NHB 5300.4(3A-1)."

TABLE OF CONTENTS

Par.		Page
CHAPTER 1. BASIC PRINCIPLES		
3I100	Applicability and Scope	1
3I101	Classification	1
3I102	Principles of Reliable Design for Printed Wiring Boards	1
3I103	General	2
3I104	Related Documents	3
3I105	Deviation and Waiver Requests	5
3I106	Rework	5
3I107	Definitions	5
CHAPTER 2. SUPPLIER RIGID PRINTED WIRING BOARD FABRICATION PROGRAM		
3I200	General	7
3I201	Training	7
3I202	Maintenance of Qualification	7
3I203	Revocation of Qualification	7
3I204	Requalification	8
3I205	Workmanship Standards	8
3I206	Documentation	8
CHAPTER 3. FACILITIES, EQUIPMENT, AND MATERIALS		
3I300	Facility Cleanliness	9
3I301	Environmental Conditions	9
3I302	Light Intensity	9
3I303	Tool and Equipment Control	9
3I304	Metal-Clad Laminates	11
3I305	Bonding Layer (Prepreg)	11
3I306	Plating or Solder Coating	11
3I307	Electroless Copper Plating	11
3I308	Electrolytic Copper Plating	11
3I309	Tin-Lead Plating	11
3I310	Solder Coating	12
3I311	Gold Plating	12
3I312	Nickel Plating	12
3I313	Solder Mask	12

Par.		Page
3I314	Marking Ink	12
3I315	Solvents	12

CHAPTER 4. ARTWORK CONSIDERATIONS

3I400	Producibility	13
3I401	Engineering Documentation	13
3I402	Quality Conformance Test Circuitry	13

CHAPTER 5. REQUIREMENTS FOR RIGID PRINTED WIRING BOARDS

3I500	General	23
3I501	Workmanship	23
3I502	Dimensions	23
3I503	Conductor Pattern	23
3I504	Conductor Width and Spacing	24
3I505	Measling and Crazing	25
3I506	Delamination	25
3I507	Undercutting	25
3I508	Conductor Outgrowth	25
3I509	Bow and Twist	25
3I510	Plating Adhesion	25
3I511	Dielectric Withstanding Voltage	25
3I512	Cleanliness	26
3I513	Marking	26
3I514	Solder Mask	26
3I515	Specific Requirements (Types 1 and 2 Without Plated-Through Holes)	27
3I516	Specific Requirements (Type 2 with Plated-Through Hole and Type 3)	29

CHAPTER 6. QUALITY ASSURANCE PROVISIONS

3I600	Responsibility for Inspection	35
3I601	Test Equipment and Inspection Facilities	35
3I602	Classification of Inspection	35
3I603	Materials Inspection	35
3I604	Inspection Conditions	35
3I605	Supplier Qualification Inspection	35
3I606	Qualification Test Specimens	36
3I607	Qualification Inspection	36
3I608	Extent of Qualification	36

Par.		Page
3I609	Failures	36
3I610	Revocation of Qualification	36
3I611	Quality Conformance Inspection	42
3I612	Inspection of Product for Delivery	42
3I613	Inspection Lot	44
3I614	Sampling Plan	44
3I615	Rejection Lots	46
3I616	Inspection of Packaging	46
3I617	Visual and Dimensional Examination	46
3I618	Plated-Through Hole Examination	47
3I619	Annular Ring Measurement (Types 1 and 2 Unplated)	48
3I620	Conductor Edge Outgrowth	48
3I621	Plating and Solder Adhesion	48
3I622	Rework Solderability (Plated-Through Holes)	49
3I623	Bow and Twist (Types 1, 2, and 3)	49
3I624	Dielectric Withstanding Voltage	49
3I625	Thermal Stress (Solder Float)	49
3I626	Hole Solderability	50
3I627	Moisture and Insulation Resistance	50
3I628	Circuitry	50
3I629	Cleanliness and Resistivity of Solvent Extract	50
3I630	Solder Mask (See 3I514)	52
3I631	Thermal Shock	54

APPENDIXES

Appendix A	Definitions	A-1
Appendix B	Procedure for Metallographic Preparation and Examination of Printed Wiring Board Test Hole Coupons	B-1
Appendix C	IPC Test Methods for Solder Mask Evaluation	C-1

CHAPTER 1: BASIC PRINCIPLES

3I100 APPLICABILITY AND SCOPE

1. **Applicability.** This publication is applicable to NASA programs involving the fabrication of rigid single-sided printed wiring boards, rigid double-sided printed wiring boards, and rigid multilayer printed wiring boards, and where invoked contractually in procurements. The parts in conformance with this standard are intended for use in aircraft, spacecraft, launch vehicles, and mission-essential support equipment.
2. **Scope.** This publication sets forth requirements for rigid printed wiring boards.
3. **Special Requirements.** Special requirements may exist which are not covered by or are not in conformance with the requirements of this publication. *Design documentation shall contain the detail for such requirements, and they shall take precedence over conflicting portions of this publication when they have been approved in writing by the procuring NASA installation.*
4. **Low Pressure or Vacuum Applications.** Materials used in low pressure or vacuum compartments shall have low emittance of condensables and noxious or toxic gases. Materials used shall be subject to NASA approval.

3I101 CLASSIFICATION

Printed wiring boards shall be of the types specified as follows:

- a. Type 1 - single-sided board.
- b. Type 2 - double-sided board.
- c. Type 3 - multilayer board.

3I102 PRINCIPLES OF RELIABLE DESIGN FOR PRINTED WIRING BOARDS

1. **Factors Controlling Reliability.** Reliable printed wiring boards result from proper design and control of processes, tools, materials, work environments, and workmanship.

2. **Design Considerations.** The basic design considerations to assure reliable printed wiring boards are as follows:
 - a. Proper selection of materials to meet anticipated electrical and mechanical requirements and environmental conditions.
 - b. Selection of line widths, spacings, and other critical dimensional characteristics to provide adequate compensation for manufacturing tolerances.
 - c. Proper sizing of holes to fit component lead sizes and/or feed-through requirements
 - d. Sizing of terminal areas to match hole sizes and provide adequate annular rings.
 - e. Optimum utilization of available space.
 - f. Accurate artwork and complete detail drawings.

3I103 GENERAL

1. **Implementation.** NASA quality assurance personnel will advise and assist contractors, suppliers, and delegated agencies in the proper and effective implementation of the provisions of this publication. Effective implementation includes establishing a system which will identify each inspection point and provide a record.
2. **Inspection.** When related requirements or changes in the requirements are specified, NASA quality assurance personnel will assure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to the actual contract requirements.
- * 3 **Qualification.** The supplier shall be qualified prior to purchase of boards produced with materials, equipment, and procedures that will be used in subsequent production. The qualification shall be to this standard or other requirements acceptable to the NASA contracting officer. Other Government standards that are accepted as proof of compliance to the qualification requirements of this document include current and active qualification status to MIL-P-55110 for the board types to be produced.

3I104 RELATED DOCUMENTS

1. **Applicable Specifications.** Copies of the following specifications, when required in connection with a specific procurement, may be obtained from the procuring NASA installation or as directed by the contracting officer:

Federal Specifications:

L-T-90, "Tape, Pressure-Sensitive, Adhesive (Cellophane and Cellulose Acetate)."

QQ-N-290, "Nickel Plating (Electrodeposited)."

QQ-S-571, "Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy."

Military Specifications:

MIL-P-116, "Preservation, Methods of."

MIL-P-13949, "Plastic Sheet, Laminated, Copper-Clad (For Printed Wiring)."

MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

MIL-C-14550, "Copper Plating (Electrodeposited)."

MIL-M-38510, "Microcircuits."

MIL-I-43553, "Ink Marking, Epoxy Base."

MIL-G-45204, "Gold Plating, Electrodeposited."

MIL-P-81728, "Plating, Tin-Lead, Electrodeposited."

MIL-STD-129, "Marking for Shipment and Storage."

MIL-STD-202, "Test Methods for Electronic and Electrical Component Parts."

MIL-STD-1188, "Commercial Packaging of Supplies and Equipment."

2. Other Publications

IPC-B-251/, "IPC Multi-Purpose Board."

IPC-B-271/, "Multilayer Printed Circuit Test Board."

IPC-TM-6501/, "Test Methods Manual."

IPC-SM-8401/, "Qualification and Performance of Permanent Polymer Coating (Solder Mask) for Printed Circuit Boards."

ASTM-E-221/, "Micrographs of Metals and Alloys, Preparation of."

ASTM E-321/, "Metallographic Specimens, Preparation of."

ASTM E-5321/, "Copper, Chemical Analysis of."

OSHA Standards, Title 29, Code of Federal Regulations, Part 1910.

1/ Application for copies should be addressed to IPC, 3451 Church St., Evanston, IL 60203.

2/ Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103.

Unless otherwise specified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

I105 DEVIATION AND WAIVER REQUESTS

- 1. Approval of Changes.** This publication requires that:
 - a. Written approval shall be obtained from the cognizant NASA Contracting Officer or designated NASA Representative for technical changes, deviations, or waivers initiated by the supplier.
 - b. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality and reliability will not be compromised.
- 2. Responsibility.** The prime contractor is responsible for assuring that any departures from this publication are evaluated, coordinated with, and submitted to the procuring NASA installation for approval prior to use or implementation.

3I106 REWORK

Rework is permissible unless excluded by other provisions of the contract. All rework shall meet the requirements of this publication. Rework is not repair. Repair shall be made only in compliance with applicable contractual requirements.

3I107 DEFINITIONS

For the purposes of this publication, the definitions in Appendix A shall apply.

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CHAPTER 2: SUPPLIER RIGID PRINTED WIRING BOARD FABRICATION PROGRAM

3I200 GENERAL

The supplier is responsible for maintaining a documented printed wiring board fabrication program that meets the requirements of this publication. Portions of this publication may be abstracted for the supplier's program.

3I201 TRAINING

The supplier is responsible for:

1. Assuring that the printed wiring board manufacturing and inspection personnel are familiar with the requirements of this publication and other pertinent requirements of the contract or purchase order.
2. Providing necessary training of the manufacturing and inspection personnel in printed wiring board fabrication, assembly, inspection, and procedures pertinent to the areas of responsibility of each in performance of the contract or purchase order.
3. Assuring that each individual who fabricates and inspects is appropriately skilled in the types of processes involved in the assigned work.
4. Maintaining appropriate records of training.

3I202 MAINTENANCE OF QUALIFICATION

Qualified sources shall be reviewed on a yearly basis for continuation of qualified status by the procuring NASA installation or its designated representative.

3I203 REVOCATION OF QUALIFICATION

Qualification may be revoked by the procuring NASA installation for any of the following reasons.

1. No boards fabricated to the requirements of this publication or other NASA specification for 1 year.
2. Delivery of boards not meeting the requirements of this publication, without the supplier taking immediate and sufficient corrective action to preclude recurrence.
3. Loss of key personnel vital to a reliable operation without qualified replacement.
4. Transfer of operations to another facility which has not been approved.

5. Use of a supplier who has not been approved to perform a specific operation.
6. Deterioration of processes or controls beyond the point of immediate corrective action.

3I204 REQUALIFICATION

Requalification shall be required after revocation of qualification for any of the reasons listed in 3I203 and may consist of a complete resurvey and retest as outlined in 3I605 through 3I609.

3I205 WORKMANSHIP STANDARDS

The supplier shall:

1. Utilize visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all types of printed wiring boards fabricated to the contract or purchase order.
2. Utilize applicable illustrations in this publication, supplemented as necessary with visual standards. Examples of unacceptable conditions may also be used for clarification or comparison.
3. Make applicable standards readily available to personnel involved with manufacturing, assembly, and inspection of printed wiring boards and use these standards in the training program.

3I206 DOCUMENTATION

Documents required herein shall be submitted to the procuring NASA installation or its designated representative as required by the contract or purchase order.

CHAPTER 3: FACILITIES, EQUIPMENT, AND MATERIALS

3I300 FACILITY CLEANLINESS

The supplier is responsible for maintaining work areas in a clean, orderly condition, as required for the production of printed wiring boards to meet the requirements of this specification. Smoking, eating, and drinking in the following critical areas shall not be permitted: film plotting, photoprint, Numerical Control (NC) drilling and routing, touchup, lamination lay-up.

3I301 ENVIRONMENTAL CONDITIONS

All areas except the critical areas listed in 3I300 shall be continuously maintained for temperature and humidity within the limits of the comfort zone in Figure 3-1. The critical areas listed above, film plotting, photoprint, N/C drilling and routing, touchup and lamination lay-up shall be controlled as special process areas and environmental conditions shall be established by the supplier and controlled within the established limits.

Parts being processed that require more critical environmental conditions than the preceding shall have such requirements identified and specified in the design documentation. Such requirements will have precedence over the established general environments.

3I302 LIGHT INTENSITY

Light intensity shall be a minimum of 100 foot-candles ($1076.4 \text{ lumens/m}^2$) on the surface where visual acuity is critical and a minimum of 80 foot-candles (861.1 lumens/m^2) in other areas. Yellow Ultra Violet (U/V) screening lights shall be used in areas where photo resist is applied and developed.

3I303 TOOL AND EQUIPMENT CONTROL

The supplier shall:

1. Check and maintain calibration of equipment and tools at regular intervals to assure proper functions, control, safety, proper cleaning and servicing.
2. Document or reference in the fabrication procedures detailed operating procedures and maintenance schedules for tools and equipment requiring calibration or setup.

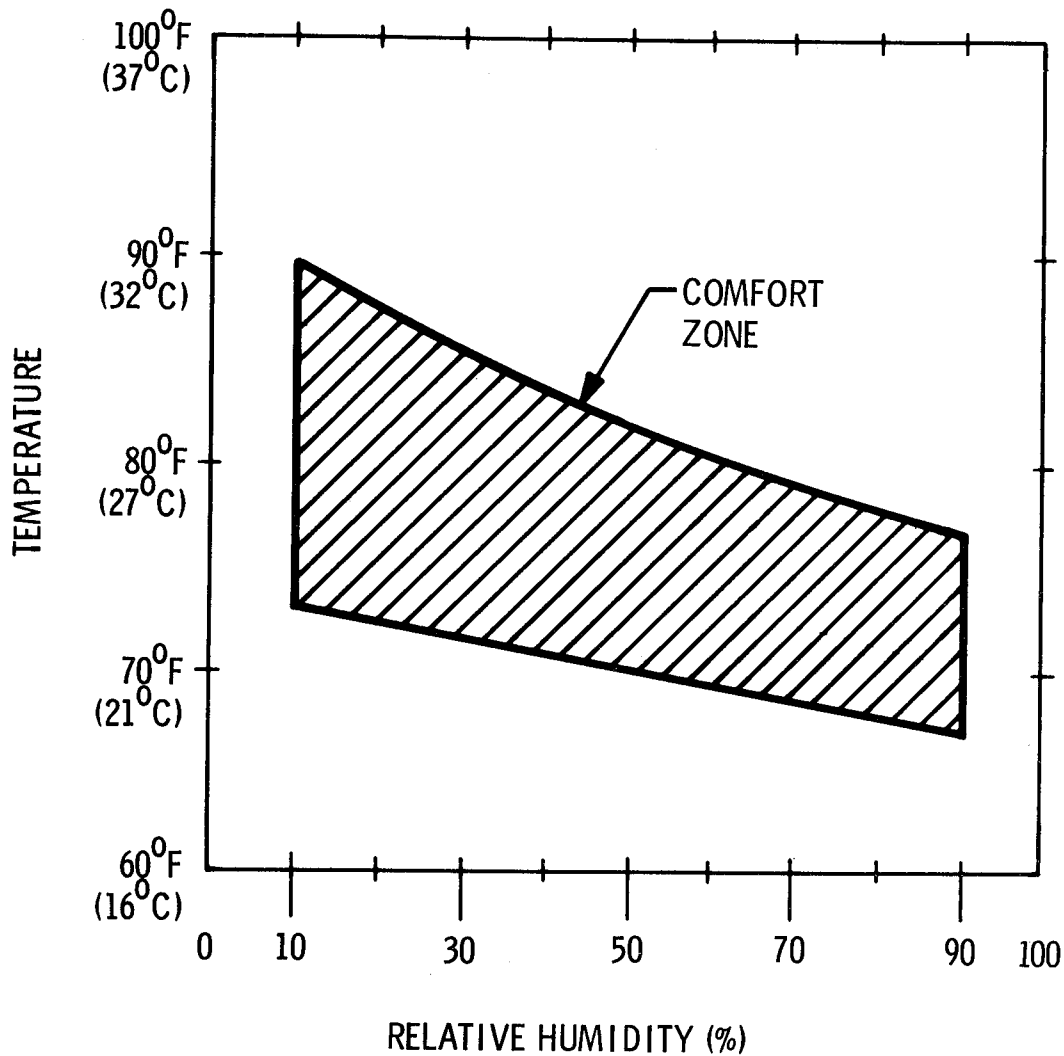


FIGURE 3-1
COMFORT ZONE:
TEMPERATURE VERSUS HUMIDITY REQUIREMENT

3. Maintain records of tool and equipment calibration and verification.
4. Develop and implement the requirements and procedures necessary to prevent damage and to control conditions that could degrade the reliability of parts and deliverable items. In particular, means shall be provided to prevent damage or contamination during handling and storage. Containers shall be compatible with materials stored.

3I304 METAL-CLAD LAMINATES

Metal-clad laminates shall be in accordance with MIL-P-13949, Types GE, GF, GI, GP, GR, GT and GX. The type, copper thickness, surface condition, and material thickness shall be specified on the approved engineering drawing. Base material for Type 3 individual layers shall be .002 inch (.05 mm) minimum thickness per sheet plus sufficient prepreg (see 3I305) to meet the minimum dielectric requirements of 3I516-5.

3I305 BONDING LAYER (PREPREG)

The bonding layers for Type 3 boards shall be preimpregnated (B-Stage) glass cloth conforming to MIL-P-13949 and of the same type as the metal-clad plastic sheet.

3I306 PLATING OR SOLDER COATING

Unless otherwise specified in the approved engineering drawing, printed wiring boards shall be solder coated or tin-lead plated and fused. When other platings are used on the same printed wiring board in conjunction with solder coating or fused tin-lead plating, there shall be no tin-lead between the other plating and the copper. When polymer mask coatings are applied over bare or black-oxidized copper (3I313), exposed circuit areas shall be solder-coated or tin-lead plated and fused. Unless otherwise specified, plating thickness shall meet the requirements of 3I515-1. This does not apply to vertical conductor edges when fused tin-lead plating is used.

3I307 ELECTROLESS COPPER PLATING

An electroless copper deposition system shall be used as a preliminary process for providing the conductive layer over nonconductive material for subsequent electrodeposition of plated-through holes.

3I308 ELECTROLYTIC COPPER PLATING

All electrolytic copper plating shall be in accordance with MIL-C-14550, and shall have a minimum purity of 99.5 percent as determined by American Society of Testing and Materials (ASTM) E 53. The minimum thickness shall meet the requirements of 3I516-3. The type of copper deposit may be specified by the procuring activity.

3I309 TIN-LEAD PLATING

Tin-lead plating shall be in accordance with MIL-P-81728. Fusing shall be required on all tin-lead plated surfaces. The fused tin-lead shall meet the thickness requirements of 3I516-3, shall be homogeneous, and shall completely cover the conductors. This is not intended to apply to vertical conductor edges.

3I310 SOLDER COATING

Solder coating shall be in accordance with composition Sn60, Sn62, or Sn63 of QQ-S-571. The solder coating thickness shall meet the thickness requirements of 3I516-3, shall be homogeneous, and shall completely cover the conductors.

3I311 GOLD PLATING

All electrolytic gold plating shall be in accordance with MIL-G-45204. The thickness shall be as specified in 3I516-3. A low-stress nickel plating (see 3I312) shall be used between gold overplating and copper. The class and type shall be as specified on the approved engineering drawing.

3I312 NICKEL PLATING

All electrolytic nickel plating shall be low stress and conform to QQ-N-290, Class 2 except the minimum thickness shall be as specified in 3I516-3.

3I313 SOLDER MASK

Polymer mask coating materials shall meet the requirements of IPC-SM-840, Class 3 and shall be specified on the approved engineering drawing.

NOTE

The solder mask is normally applied over bare copper, or bare copper with a black or red oxide treatment.

3I314 MARKING INK

Marking ink shall be an epoxy-base ink conforming to MIL-I-43553.

3I315 SOLVENTS

Solvents shall be nonconductive and noncorrosive, and shall not degrade the quality of the material. Solvents shall be properly labeled and maintained in a clean and uncontaminated condition. Those showing evidence of contamination or decomposition shall not be used.

CAUTION!

All solvents and chemicals may present health and safety problems. Follow OSHA precautions and guidelines for handling.

CHAPTER 4: ARTWORK CONSIDERATIONS

3I400 PRODUCIBILITY

The fabricator shall be responsible for reviewing the artwork and engineering documentation provided for each individual printed wiring board configuration, prior to the start of manufacturing to assure that the requirements of this standard can be met. If discrepancies exist, the procuring authority shall be notified.

3I401 ENGINEERING DOCUMENTATION

In addition to the artwork, the documentation shall include a master drawing which establishes the type, size, and shape of the printed wiring board, the size and location of all holes therein, whether etchback is required, location of traceability markings, dielectric separation between layers, and the shape and arrangement of both conductor and nonconductor patterns or elements. Any and all pattern features not controlled by the hole sizes, locations, or master pattern shall be adequately dimensioned, either specifically or by notes.

3I402 QUALITY CONFORMANCE TEST CIRCUITRY

1. Type 1 and Type 2

When specified on the approved engineering drawing, a quality conformance test coupon as shown on the drawing, or in accordance with Figure 4-1 shall be included in each production run. The number of coupons and their locations on the panel(s) shall be indicated on the approved engineering drawing.

2. Type 3

A quality conformance test coupon in accordance with Figure 4-3 shall be included at least once on the panel (see Figure 4-2). The quality conformance test coupon shall also be included on the approved engineering drawing and artwork.

3. On all Type 3 printed wiring boards and Types 1 and 2 unless otherwise specified, the test coupon shall be within .5 inch (12.7 mm) of the edge of the board and be located as shown in Figure 4-2.

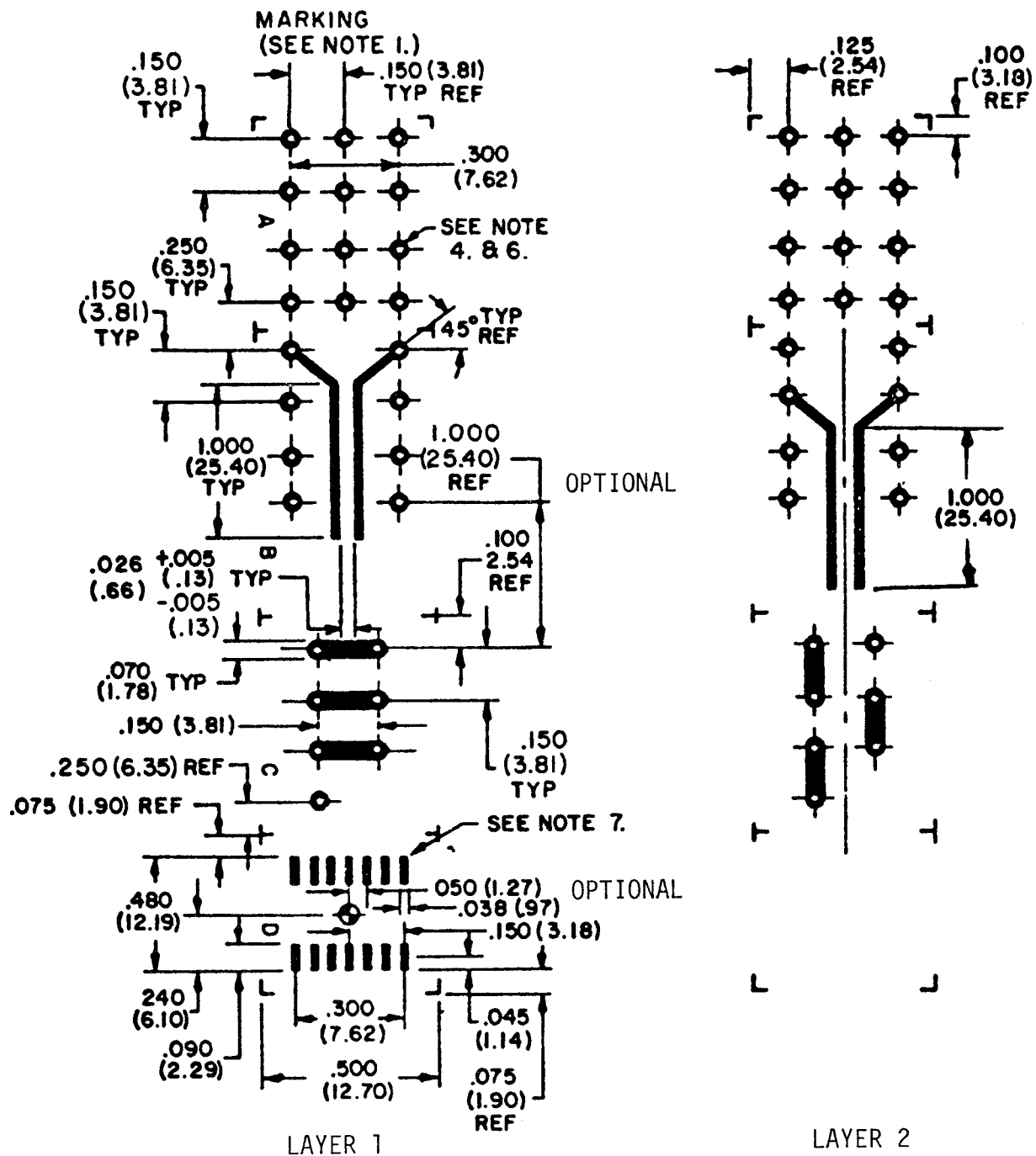


FIGURE 4-1
QUALITY CONFORMANCE TEST COUPON FOR TYPE 1 AND TYPE 2
PRINTED-WIRING BOARDS

NOTES:

1. TEST COUPONS ARE TO BE IDENTIFIED WITH THE FOLLOWING DATA:

- A. FEDERAL SUPPLY CODE FOR MANUFACTURERS (FSCM) .
- B. PART NUMBER AND REVISION LETTER .
- C. BOARD TRACEABILITY OR LOT NUMBER .

CHARACTERS MUST BE LEGIBLE: STYLE, HEIGHT AND WIDTH ARE OPTIONAL .

- 2. TEST COUPONS SHALL BE AN INTEGRAL PART OF ALL MASTER DRAWINGS AND FABRICATION ARTWORK.
- 3. THE ETCHED LETTERS ON THE COUPONS ARE FOR IDENTIFICATION PURPOSES ONLY.
- 4. ALL PADS SHALL BE 0.070 INCH (1.78 MM) \pm .005 (.13 MM) DIAMETER. HOLES SHALL BE THE DIAMETER OF THE SMALLEST HOLE IN THE ASSOCIATED BOARD.
- 5. ALL CONDUCTORS SHALL BE .020 INCH (.51 MM) \pm .003 (.08 MM) WIDE, UNLESS OTHERWISE SPECIFIED.
- 6. ALL HOLE TOLERANCES SHALL MEET THE REQUIREMENTS OF THE END PRODUCT BOARD.
- 7. THE NOTED TARGET \blacklozenge REPRESENTS THE THEORETICAL CENTERLINES OF THE COUPON.

ALL TOLERANCES SHALL BE \pm .001 (.03 MM) ON THE FABRICATION ARTWORK.

- 8. DIMENSIONS ARE IN INCHES.
- 9. MILLIMETERS ARE IN PARENTHESES.
- 10. METRIC EQUIVALENTS ARE GIVEN FOR GENERAL INFORMATION ONLY AND ARE BASED UPON 1.00 INCH = 25.4 MM.
- 11. COUPONS "B" AND "D" ARE NOT REQUIRED BY TABLE 6-3 FOR QUALITY CONFORMANCE INSPECTION BUT MAY BE USED FOR ADDITIONAL TESTING IF REQUIRED.

FIGURE 4-1
QUALITY CONFORMANCE TEST COUPON FOR TYPE 1 AND TYPE 2
PRINTED-WIRING BOARDS (CONTINUED)

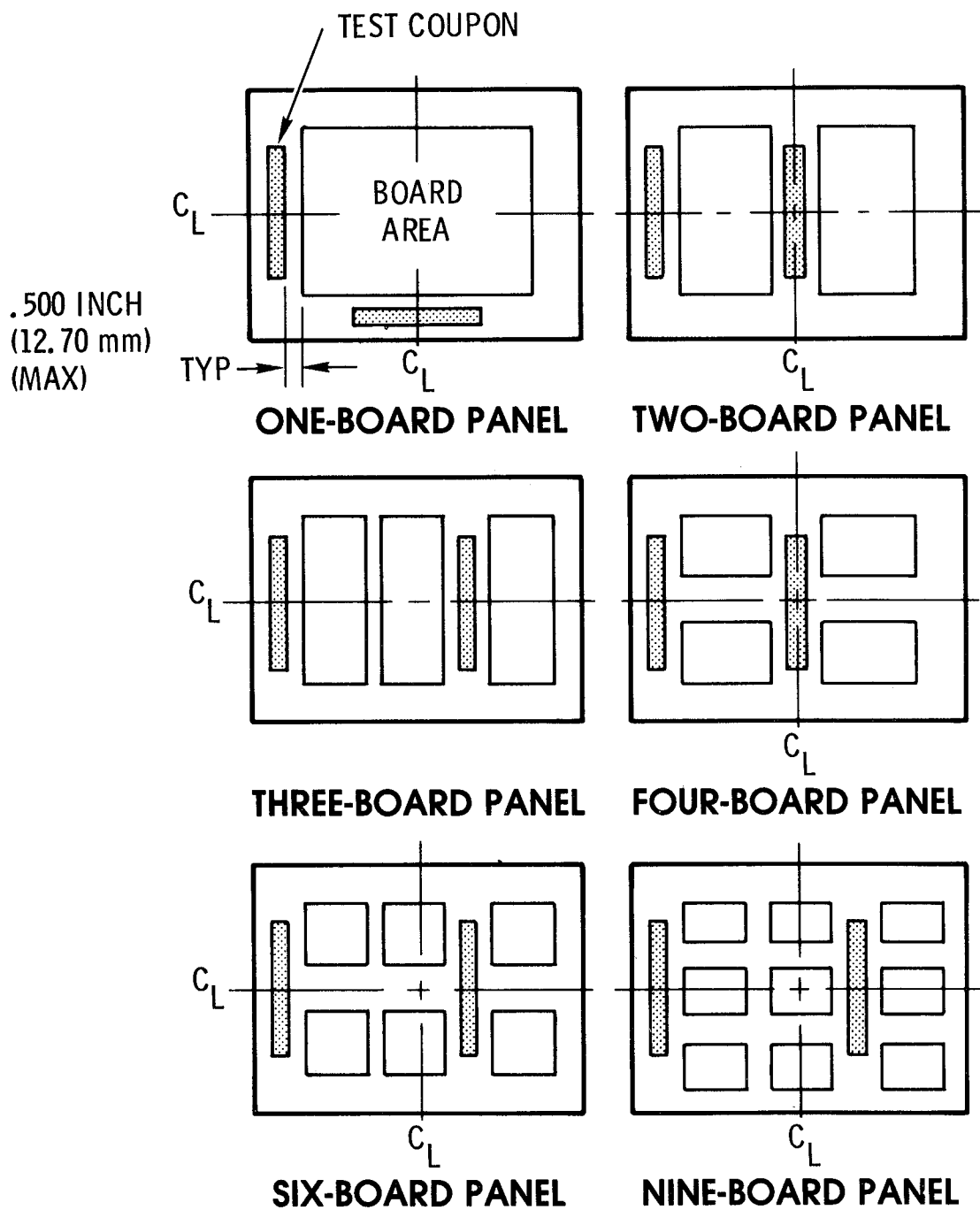


FIGURE 4-2
TYPICAL LOCATION OF TEST COUPON BASED ON NUMBER OF BOARDS
FABRICATED FOR EACH PANEL TYPES 1, 2, AND 3

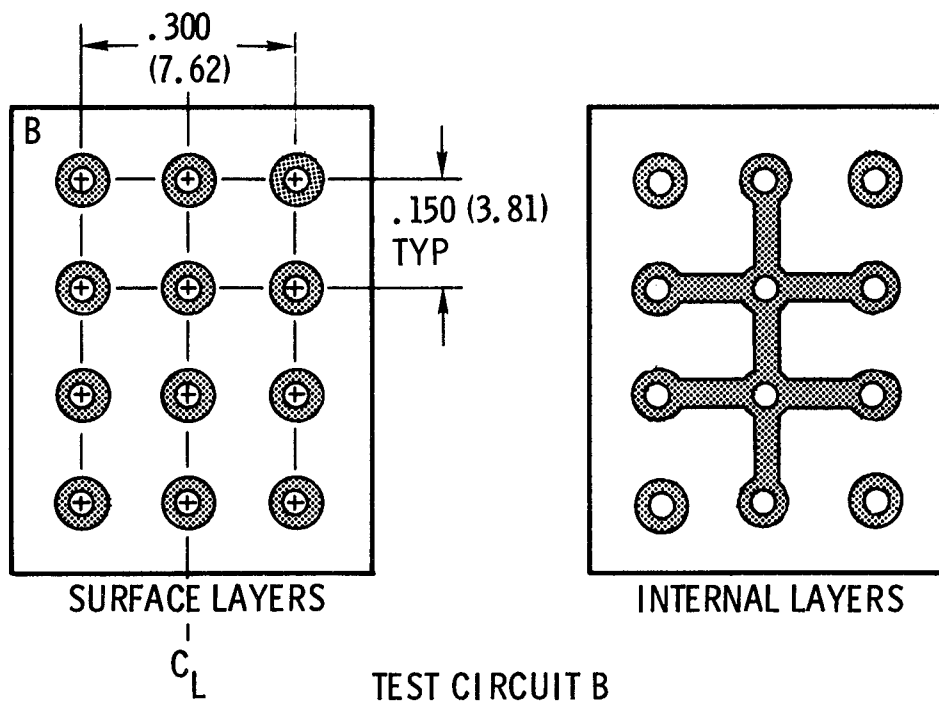
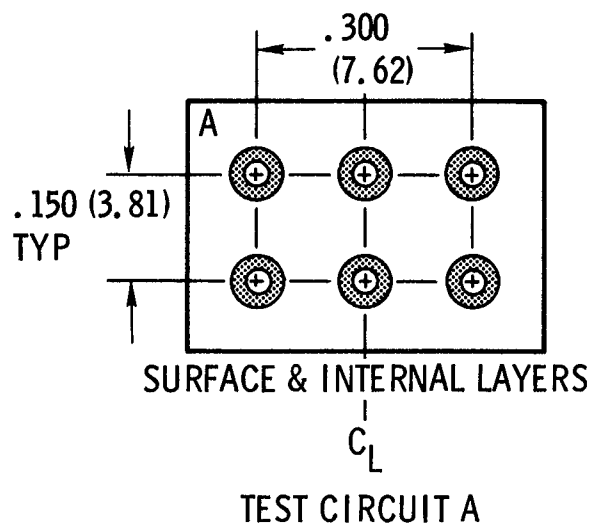
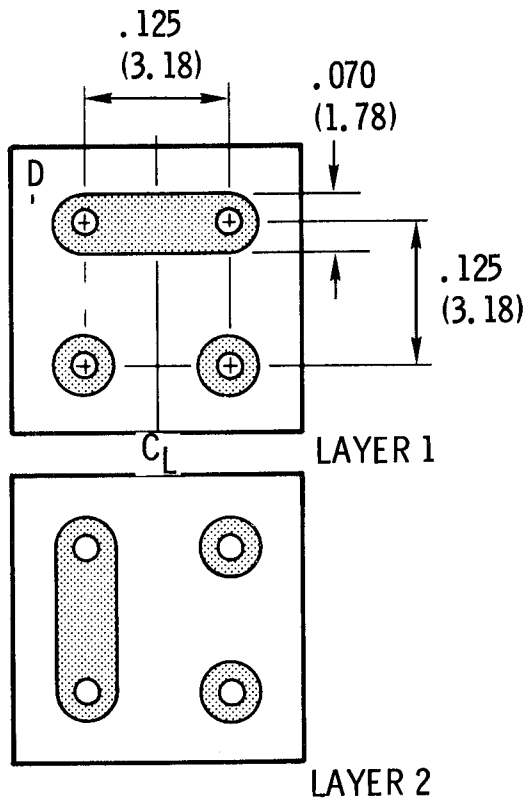
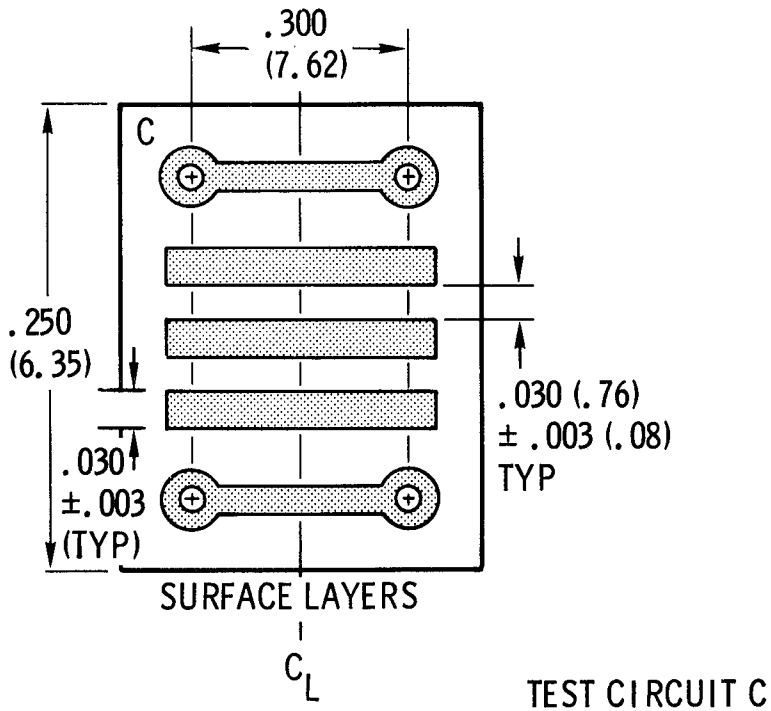
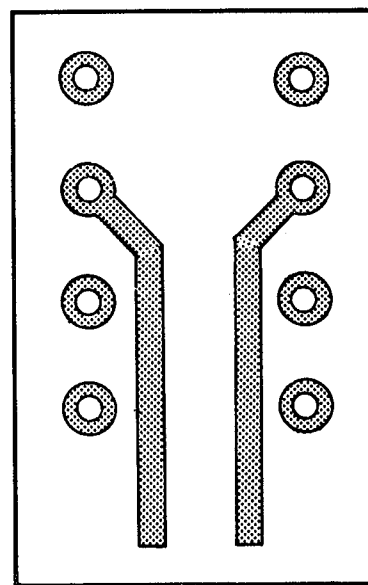
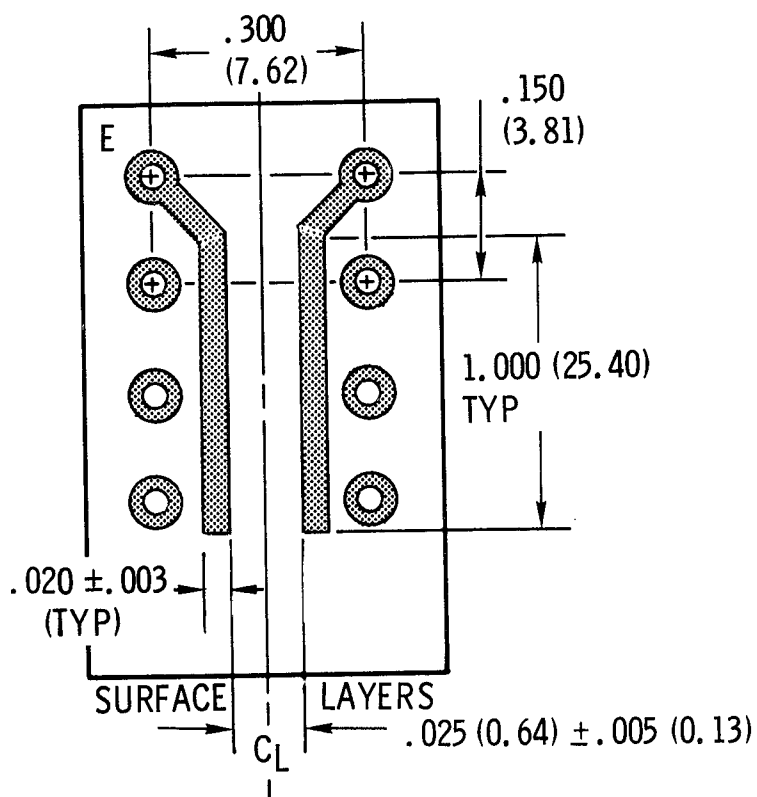


FIGURE 4-3
QUALITY CONFORMANCE TEST COUPON (TYPE 3)



SEE NOTE 5 AND 6

FIGURE 4-3
QUALITY CONFORMANCE TEST COUPON (TYPE 3) (CONTINUED)



TEST CIRCUIT E (OPTIONAL)

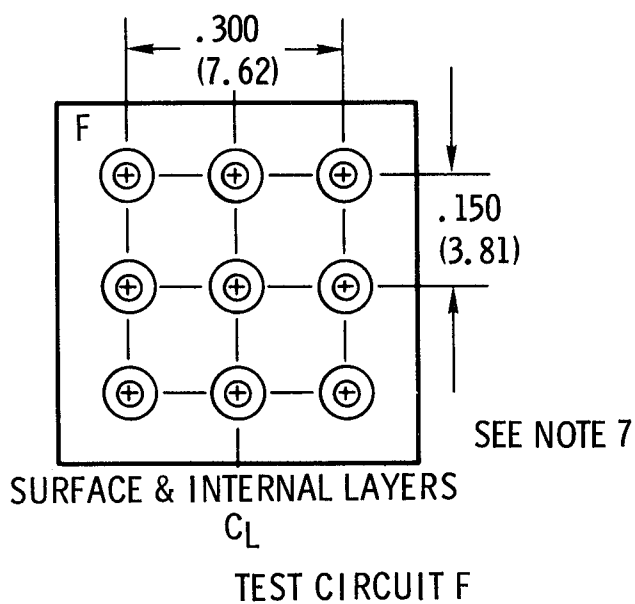
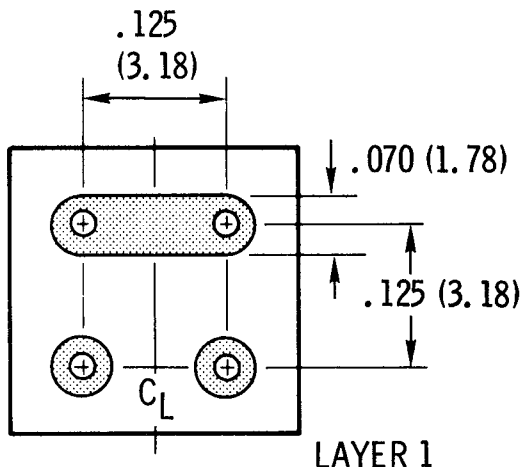
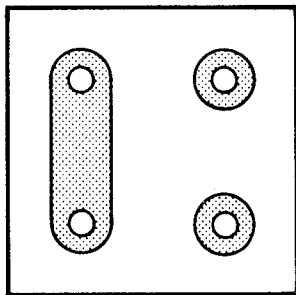


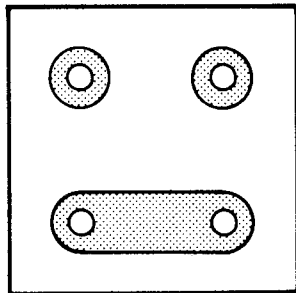
FIGURE 4-3
QUALITY CONFORMANCE TEST COUPON (TYPE 3) (CONTINUED)



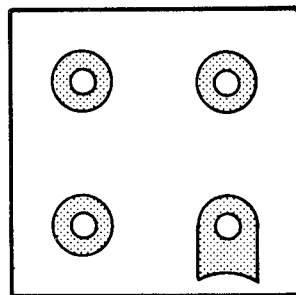
LAYER 1



LAYER 2



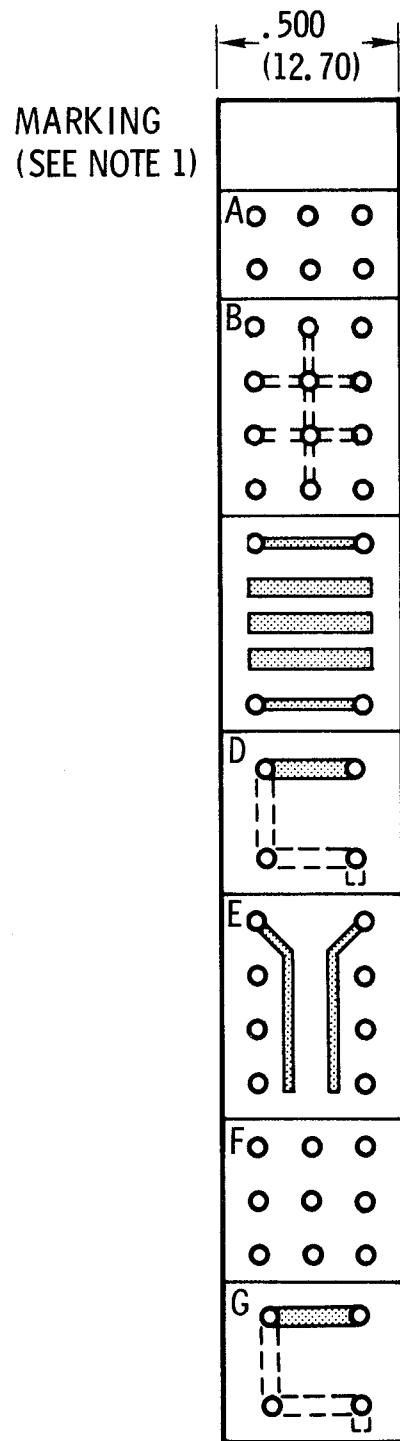
LAYER 3



LAYER 4

SEE NOTE 5 AND 6.

TEST CIRCUIT G (OPTIONAL)



QUALITY CONFORMANCE
TEST COUPON LAYOUT

FIGURE 4-3
QUALITY CONFORMANCE TEST COUPON (TYPE 3) (CONTINUED)

NOTES:

1. TEST COUPONS ARE TO BE IDENTIFIED WITH THE FOLLOWING DATA:
 - A. FSCM.
 - B. PART NUMBER AND REVISION LETTER.
 - C. BOARD TRACEABILITY OR LOT NUMBER.
2. ALL LINES SHALL BE .020 (.51 MM) \pm .003 (.08 MM) WIDE, UNLESS OTHERWISE SPECIFIED.
3. UNLESS OTHERWISE SPECIFIED, THE TOLERANCES SHALL MEET THE REQUIREMENTS OF THIS SPECIFICATION.
4. THE MINIMUM LAND DIMENSION SHALL BE .070 (1.78 MM) \pm .005 (.13 MM) AND MAY REPRESENT THE PAD SHAPE USED ON THE ASSOCIATED BOARD. HOLES IN TERMINAL AREAS SHALL BE THE DIAMETER OF THE SMALLEST HOLE IN THE ASSOCIATED BOARD (SEE NOTE 7).
5. ALL FIRST LAYERS AND INTERNAL LAYERS SHALL BE AS SPECIFIED ON THE MASTER DRAWING. COPPER PLANE AREAS MAY BE USED ON ALL COUPONS ON APPROPRIATE PLANE LAYERS, EXCEPT FOR THE D, E, AND G SEGMENTS.
6. THE LENGTHS OF TEST CIRCUITS D, E, AND G, ARE DEPENDENT ON THE NUMBER OF LAYERS IN THE PANEL. FOR TEST CIRCUITS D AND G, A PAIR OF HOLES AND A CONDUCTOR BETWEEN SAME SHALL BE PROVIDED FOR EACH LAYER. ELECTRICAL CONNECTION SHALL BE IN SERIES, STEPWISE, THROUGH EACH CONDUCTOR LAYER OF THE BOARD. FOR TEST CIRCUIT E, A PAIR OF HOLES AND CONDUCTORS MUST BE PROVIDED FOR THE FIRST LAYER AND EACH INTERNAL LAYER.
7. FOR COUPON F, THE MINIMUM LAND DIMENSION AND SHAPE SHALL BE THAT USED ON THE ASSOCIATED BOARD. THE HOLE SHALL BE THE MAXIMUM USED IN THE SMALLEST LAND USED FOR LEAD INSERTION.
8. THE QUALITY CONFORMANCE TEST CIRCUITRY MAY BE SEGMENTED, HOWEVER TEST CIRCUITRY A, B, AND F MUST BE JOINED TOGETHER. TEST CIRCUITRY C, D, G, AND E MAY BE ARRANGED TO OPTIMIZE BOARD LAYOUT. ALL TEST COUPONS ILLUSTRATED MUST APPEAR ON EACH PANEL. THE NUMBER OF LAYERS MUST BE IDENTICAL TO THE NUMBER OF LAYERS IN THE BOARDS DERIVED FROM THE PANELS.
9. ETCHED LETTERS ON COUPONS ARE FOR IDENTIFICATION PURPOSES ONLY.
10. NUMBER OF LAYERS SHOWN IN THESE TEST COUPONS ARE FOR ILLUSTRATION PURPOSES ONLY. CONDUCTOR LAYER NUMBER 1 SHALL BE THE LAYER ON THE COMPONENT SIDE, AND ALL OTHER CONDUCTOR LAYERS SHALL BE COUNTED CONSECUTIVELY DOWNWARD THROUGH THE LAMINATED BOARD TO THE BOTTOM CONDUCTOR LAYER WHICH IS THE SOLDER SIDE.
11. DIMENSIONS ARE IN INCHES.
12. MILLIMETERS ARE IN PARENTHESES.
13. METRIC EQUIVALENTS ARE GIVEN FOR GENERAL INFORMATION ONLY AND ARE BASED UPON 1.00 INCH = 25.4 MM.
14. COUPONS "D", "E", AND "G" ARE NOT REQUIRED BY TABLE 6-3 FOR QUALITY CONFORMANCE INSPECTION, BUT MAY BE USED FOR ADDITIONAL TESTING IF REQUIRED.

FIGURE 4-3
QUALITY CONFORMANCE TEST COUPON (TYPE 3) (CONTINUED)

CHAPTER 5: REQUIREMENTS FOR RIGID PRINTED WIRING BOARDS

3I500 GENERAL

1. **Facility Approval.** Items furnished in accordance with this publication shall have been processed at facilities which have been surveyed and approved.
2. **General Requirements.** The fabricated printed wiring boards (Types 1, 2, and 3) shall be in accordance with the approved engineering drawing and this publication. The production panels shall incorporate the quality conformance test circuit (test coupon) at some location around the printed wiring pattern periphery (see Figure 4-2) for Type 3 and when specified, for Types 1 and 2. Unless otherwise specified, test coupon artwork shall conform to Figures 4-1 or 4-3. When test coupons are not provided on Type 1 and 2 boards, a production board shall be used in lieu of the test coupon. When solder mask coating is specified, test coupons shall be coated in the same manner as the production boards.

3I501 WORKMANSHIP

Printed wiring boards shall be processed in such a manner as to be uniform in quality and free from defects in excess of those allowed in this document.

3I502 DIMENSIONS

1. The accuracy of the hole pattern shall be as specified on the approved engineering drawing.
2. Finished printed wiring boards shall meet the dimensional requirements specified herein and on the approved engineering drawing.

3I503 CONDUCTOR PATTERN

The conductor pattern shall be formed by etching or a combination of etching and plating of the metal foil of all printed wiring layers.

31504 CONDUCTOR WIDTH AND SPACING

Unless otherwise specified on the approved engineering drawing, isolated reductions of 20 percent or less of any conductor width or spacing caused by any combinations of edge roughness, nicks, pinholes or scratches shall be acceptable. The conductor width or spacing remaining at the point of reduction shall be 80 percent of the remaining conductor width or spacing specified on the approved engineering drawing. Under no circumstances shall the edges of the conductors have a roughness that exceeds .005 inch (.13 mm) or 20 percent of the line width, whichever is less, from peak to valley as measured over any .5 inch (13 mm) length (see Figure 5-1).

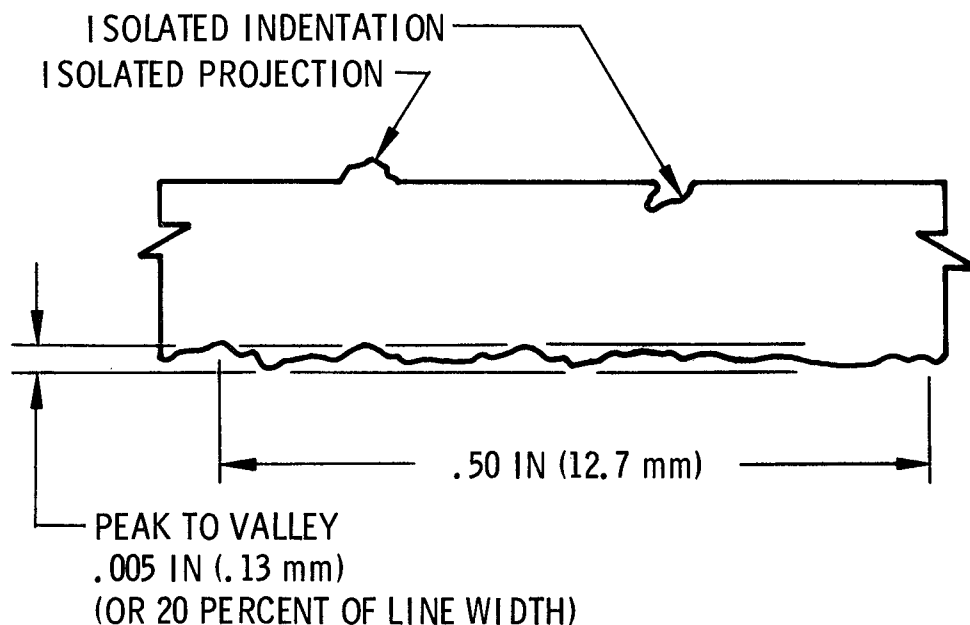


FIGURE 5-1
EDGE ROUGHNESS

3I505 MEASLING AND CRAZING

Measling, crazing, or white spots below the board surface are acceptable if the total area affected does not exceed 1 percent of the board area and there is no more than 25 percent reduction in space between electrically uncommon conductors. The edge of the printed wiring board may show evidence of crazing, haloing, or chipping, provided it does not extend into the board closer to the nearest conductor than the established minimum electrical spacing, or .060 inch (1.52 mm), whichever is less.

3I506 DELAMINATION

There shall be no delamination of the individual layers or plies of the board.

3I507 UNDERCUTTING

Undercutting at each edge of the conductors shall not exceed the total thickness of clad and plated copper.

3I508 CONDUCTOR OUTGROWTH

There shall be no outgrowth on conductor edges finished with fused tin-lead plating or solder coating. The maximum permissible outgrowth on conductors plated with other than the above metals shall be .001 inch (.025 mm).

3I509 BOW AND TWIST

When tested as specified in 3I623, the maximum allowable bow and twist shall be 1.5 percent, unless otherwise specified on the approved engineering drawing.

3I510 PLATING ADHESION

When tested as specified in 3I621, there shall be no evidence of the plating or coating being removed as shown by particles adhering to the tape or by separation of the plating or coating from the circuit pattern. If the metal outgrowth breaks off (slivers) and/or adheres to the tape, this is evidence of outgrowth (see 3I508) but not plating adhesion failure.

3I511 DIELECTRIC WITHSTANDING VOLTAGE

When tested in accordance with 3I624, there shall be no dielectric breakdown of circuits.

3I512 CLEANLINESS

When tested as specified in 3I629, printed wiring boards shall be free of ionic and other contaminants such as dirt, oil, corrosion, corrosive products, salts, smut, grease, fingerprints, mold release agents, foreign matter or flux residue and the resistivity of the wash solution shall not be less than 2,000,000 ohm-centimeter. The equivalent test method and factors specified in the note attached to 3I629 may be used in lieu of the method specified in 3I629.

3I513 MARKING

Unless otherwise specified, each individual board and each set of quality conformance test coupons shall be marked in accordance with the approved engineering drawing, with the date and manufacturer's code (Federal Supply Code for Manufacturers). For traceability, the quality conformance test coupon shall be identified with corresponding production boards produced on the panel of that coupon. The marking shall be produced by the same process used in producing the conductor pattern, by the use of marking ink or by the use of an electric pencil on a copper pad provided for marking purposes. Etched marking shall not reduce the spacing requirements specified on the master drawing. All marking shall be compatible with materials and parts, legible after all tests, and in no case shall affect board performance.

3I514 SOLDER MASK

Cured solder mask coatings shall meet the following requirements. Prior to coating, boards shall meet the cleanliness requirements of 3I512.

1. **Appearance.** When solder mask coatings are examined as specified in 3I630-1, the material shall be uniform in appearance and shall be free of foreign material, inclusions, peeling, and roughness that would interfere with the assembly or operation of the printed board.
2. **Visual Requirements.** Unless otherwise specified, scratches, pinholes, and other forms of voids shall be allowed if the conductors to be masked are covered.
3. **Dimensional Requirements.** Unless otherwise specified, the minimum thickness of the cured solder mask shall be .001 inch (.025 mm) when measured at the center of a masked conductor.
4. **Abrasion Resistance.** When tested as specified in 3I630-3 the cured solder mask shall not be scratched by a pencil which is softer than an "F" hardness.
5. **Cure.** The cured solder mask coating shall not exhibit tackiness, blistering, delamination or color change when tested as specified in 3I630-4.

6. **Resistance to Solvents and Fluxes.** The cured solder mask coating shall not exhibit a degradation in adhesion and surface characteristics such as surface roughness, tackiness, blistering or color change when tested as specified in 3I630-5.
7. **Hydrolytic Stability/Aging.** The cured solder mask coating shall show no evidence of degradation such as blistering, cracking or tackiness when tested as specified in 3I630-6.
8. **Solderability.** After application and curing, the solder mask coating shall not adversely affect the solderability of the uncoated portions of the printed board when tested as specified in 3I630-7. Solder shall completely wet the copper areas designated to be a part of the finished solder connection.
9. **Solder Resistance.** The solder mask coating shall completely resist the adherence of solder when tested as specified in 3I630-7.
10. **Soldering and Unsoldering.** The cured solder mask coating shall not exhibit separation from either the base laminate or conductors of the printed board after five cycles of soldering and unsoldering when tested as specified in 3I630-8.
11. **Moisture and Insulation Resistance.** When tested as specified in 3I627, the solder-mask coated sample shall not exhibit any blistering, separation or convolutions. The insulation resistance shall be 500 megohms minimum.

3I515 SPECIFIC REQUIREMENTS (TYPES 1 AND 2 WITHOUT PLATED-THROUGH HOLES)

In addition to the requirements detailed in 3I501 through 3I513, Type 1 and Type 2 boards without plated-through holes shall meet the following:

1. **Plating or Coating Thickness.** Plating or coating thickness shall conform to the requirements specified in Table 5-1 unless otherwise specified on the approved engineering drawing.
2. **Angular Ring.** The minimum ring shall be .015 inch (.38 mm) when measured as specified in 3I619. See Figure 5-2.

TABLE 5-1
PLATING OR COATING THICKNESS

Plating or Coating Material	Minimum Surface Thickness Inches (mm)
Gold	.00005 inch min (.0013 mm)
Nickel	.0002 inch min (.005 mm)
Tin-lead, fused <u>1/</u>	.0003 inch min (.008 mm)
Solder coat <u>1/</u>	.0003 inch min (.008 mm)

1/ Thickness shall be measured at the crest of the conductor.

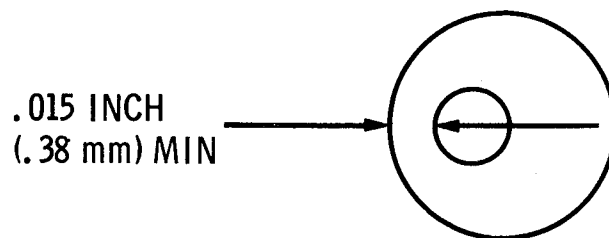


FIGURE 5-2
MINIMUM ANNULAR RING (UNSUPPORTED HOLE)

3I516 SPECIFIC REQUIREMENTS (TYPE 2 WITH PLATED-THROUGH HOLE AND TYPE 3)

Plated-through holes of Type 2 boards with plated-through holes and Type 3 boards shall be formed by a combination of electroless copper plating (3I307) and electrolytic copper plating (3I308), and shall be overplated with either tin-lead plating (3I309) or solder coating (3I310).

In addition to the requirements detailed in 3I501 through 3I513, Type 2 boards with plated-through holes and Type 3 boards shall meet the following:

1. **Plated-through hole.** Plated-through holes shall be examined in the vertical cross section in accordance with 3I618-1. They shall be free of the following defects. See Figures 5-3 and 5-4.
 - a. Layer-to-layer misregistration exceeding limits specified in 3I516-6.
 - b. Cracks in the plated copper or internal foils.
 - c. Resin smear in Type 3 printed wiring boards.
 - d. Separation at conductor interfaces (Type 3).
 - e. Separation between plated layers (Types 2 and 3).
 - f. Nailheading of internal interfaces exceeding 50 percent of the thickness of the copper foil (Type 3).
 - g. Plating thickness less than the minimum requirements of 3I516-3.
 - h. Plating voids in the plated-through hole.
 - i. Etchback (when specified) in excess of .003 inch (.08 mm) or less than .0002 inch (.005 mm).
 - j. Delamination.
 - k. Resin recession with a maximum depth in excess of .003 inch (.08 mm) or along the side of the plated-through hole for a distance in excess of 40 percent of the cumulative base material thickness (sum of the layer thicknesses being evaluated) on the side of the plated-through hole being evaluated.
 - l. Laminate voids away from the plated barrel more than .003 inch (.08 mm) in diameter.

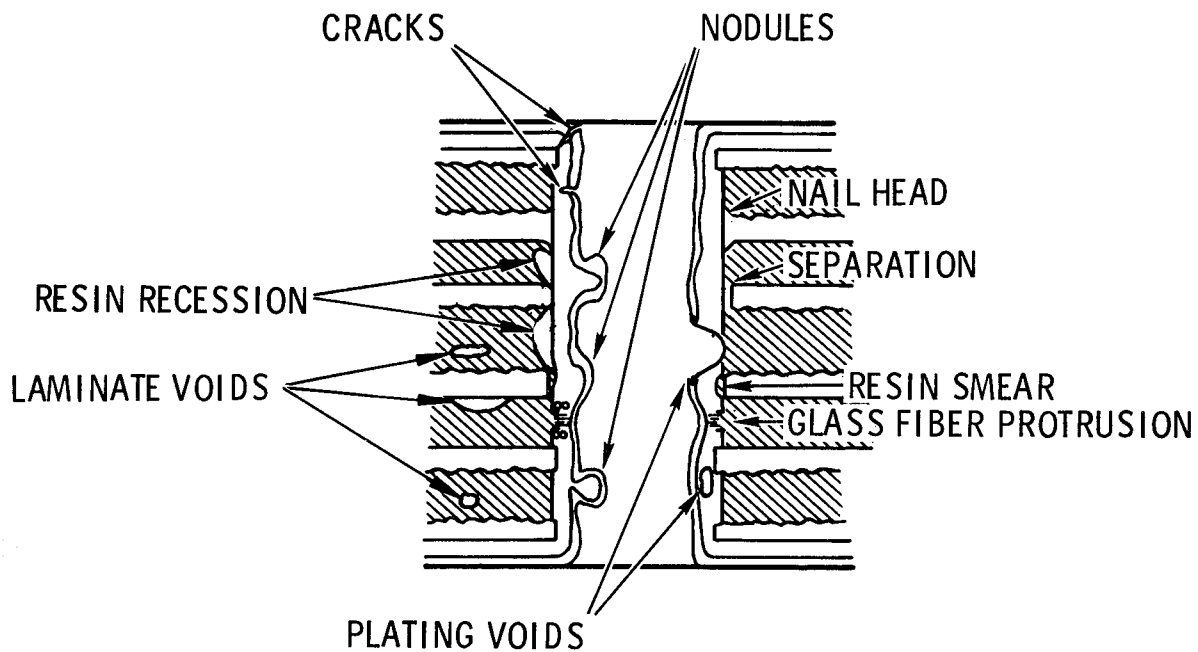


FIGURE 5-3
DEFECTS IN MULTILAYER PRINTED WIRING BOARD

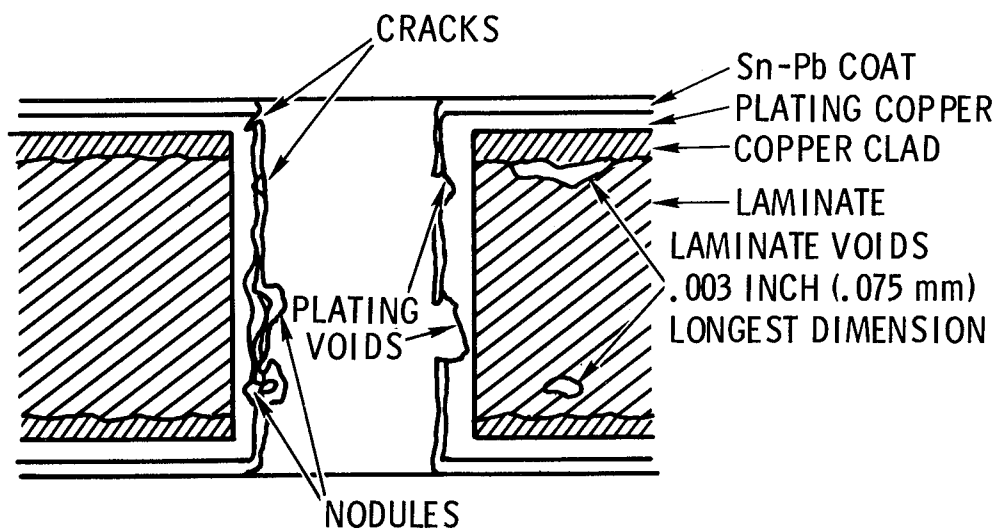


FIGURE 5-4
CRACKS, NODULES, AND VOIDS IN DOUBLE-SIDED
PRINTED WIRING BOARD

- m. Nodules that reduce the hole diameter below minimum drawing requirements.
 - n. Glass fiber protrusion reducing the plating thickness below the minimum specified on the approved engineering drawing.
2. **Hole Cleaning and Etchback (Type 3 only).** Holes shall be processed to remove all traces of resin smear and contaminants from the surfaces of the exposed internal copper rings. When etchback is specified on the approved engineering drawing, it shall be .0002 inch (.005 mm) minimum and .003 inch (.08 mm) maximum when measured at the internal copper contact area protrusion with a preferred depth of .0005 inch (.013 mm) (see Figure 5-5). Wicking may extend an additional .003 inch (.08 mm). The etchback shall be effective on at least the top or bottom surface of each internal conductor (see Figure 5-5).

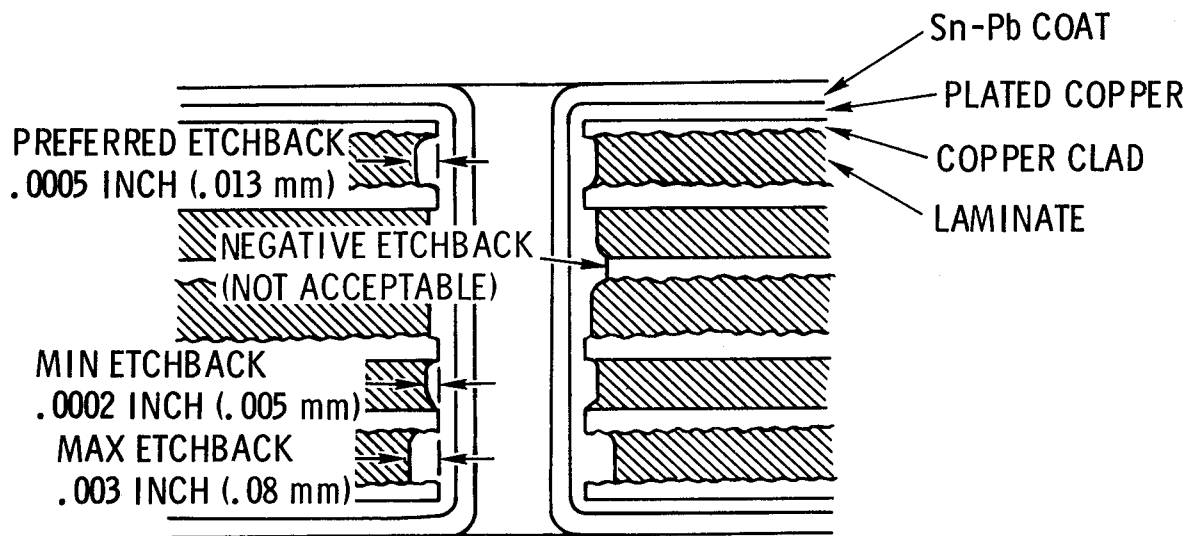


FIGURE 5-5
MULTILAYER PRINTED WIRING BOARD

3. **Plating or Coating Thickness.** Plating or coating thickness shall conform to the requirements specified in Table 5-2 unless otherwise specified on the approved engineering drawing.

TABLE 5-2
PLATING OR COATING THICKNESS
(PLATED-THROUGH HOLES)

Plating or Coating Material	Minimum Surface and Through-Hole Plating or Coating Thickness, Inches (mm)
Electroless copper	Sufficient for subsequent electrodeposition
Electrolytic copper <u>1/</u>	.001 in. min (.025 mm)
Gold	.00005 in. min (.0013 mm)
Nickel	.0002 in. min (.005 mm)
Tin-lead, fused <u>2/</u>	.0003 in. min (.0076 mm)
Solder coat <u>2/</u>	* .0003 in. min (.0076 mm)

1/ Thinnest point shall be .001 inch (.025 mm) or greater.

2/ Thickness shall be measured at the crest of the conductor or at the crest in the hole, as applicable. A plating of .0001 inch min (.002 mm) in the hole is acceptable.

4. **Annular Ring.** When measured as specified in 3I618-4, the minimum annular ring for plated-through holes shall be as follows:

External - .005 inch (.13 mm)

Internal (Type 3 only) - .002 inch (.05 mm)

5. **Dielectric Layer Thickness (Type 3).** Finished Type 3 boards shall have a minimum of .0035 inch (.09 mm) of dielectric material between the consecutive conductor layers, when cured. The dielectric material shall be comprised of laminate, prepreg and laminate, or multiple layers of prepreg. There shall be no less than two sheets of prepreg used between each pair of adjacent conductor layers.

6. **Layer-to-Layer Registration.** Unless otherwise specified on the approved engineering drawing, the misregistration shall not exceed .014 inch (.36 mm) when measured in accordance with 3I618-3.

7. **Thermal Stress.** When tested as specified in 3I625, the specimen shall exhibit no cracking, separation of plating and conductors, blistering or delamination. Measling, crazing or white spots below the board surface are acceptable if the total area affected does not exceed 2 percent of the board area and there is no more than 50 percent reduction in space between electrically uncommon conductors. Resin recession at the interface of the hole wall and plated through hole barrel shall be permitted provided the maximum depth as measured from the barrel wall does not exceed .003 inch (.08 mm) and the resin recession on any side of the plated-through hole does not exceed 40 percent of the cumulative base material thickness (sum of the layer thicknesses being evaluated) on the side of the plated-through hole being evaluated. (See Figure 5-3.)
8. **Hole Solderability.** After thermal stress testing as specified in 3I625 the solder shall cover the plated-through hole surface entirely, wetting the walls, and shall extend outward completely around the hole, wetting the terminal area.
9. **Rework Solderability.** When tested as specified in 3I622, the cross section of the plated-through holes shall meet the requirement of 3I516-7 and 3I516-8 after five cycles of soldering and unsoldering.
10. **Circuitry (Type 3 Only)**
 - a. *Circuit Shorts (Insulation Resistance).* When tested as specified in 3I628-1, the insulation resistance between mutually insulated conductors shall be greater than 100 megohms.
 - b. *Circuit Continuity.* When tested as specified in 3I628-2, there shall be no open circuits in the specimen.
11. **Thermal Shock.** When tested in accordance with 3I631, the specimen shall meet the circuitry requirement (see 3I516-10) and shall exhibit no measling or crazing in excess of that allowed in 3I516-7, and no cracking, separation of the plating and conductors, blistering, or delamination.

CHAPTER 6: QUALITY ASSURANCE PROVISIONS

3I600 RESPONSIBILITY FOR INSPECTION

Unless otherwise specified in the contract or purchase order, the processing facility shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the processing facility may use its own or any other facility, subject to contractor approval. NASA reserves the right to perform any of the inspections set forth in the specification, where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

3I601 TEST EQUIPMENT AND INSPECTION FACILITIES

The supplier shall provide and maintain test and measurement equipment and inspection facilities sufficient to perform the required inspections. Accuracy of the measuring and test equipment shall be assured by means of a calibration system as required in 3I303.

3I602 CLASSIFICATION OF INSPECTION

The inspections specified herein are classified as follows:

1. Materials inspection (see 3I603).
2. Supplier qualification inspection (see 3I605).
3. Quality conformance inspection (see 3I611).

3I603 MATERIALS INSPECTION

Materials inspection shall assure that the materials listed in Table 6-1, used in fabricating the boards, are in accordance with the applicable referenced specifications or requirements.

3I604 INSPECTION CONDITIONS

Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the General Requirements of MIL-STD-202.

3I605 SUPPLIER QUALIFICATION INSPECTION

When required, qualification inspection shall be performed at a laboratory acceptable to the procuring NASA installation, on the test specimens produced with material, equipment, and procedures that will be used in subsequent production.

TABLE 6-1
MATERIALS INSPECTION

Material	Requirement Paragraph	Applicable Specification
Metal-clad laminate	3I304	MIL-P-13949
Bonding material	3I305	MIL-P-13949
Solder coating or tin-lead plating	3I306, 3I309, 3I310	MIL-P-81728 or QQ-S-571
Permanent solder mask coating	3I313	IPC-SM-840
Marking ink	3I314	MIL-I-43553

3I606 QUALIFICATION TEST SPECIMENS

The test specimens shall consist of two test boards identified as Board 1 and Board 2, utilizing the artwork specified in IPC-B-27 for multilayer or IPC-B-25 for two-sided circuit boards (see Figures 6-1 and 6-2), in conformance to the requirements of this specification. Alternatively, two boards of an actual production configuration, together with the associated test coupons, may be substituted for qualification purposes. Separate qualification will be required for each resin system employed, i.e., MIL-P-13949/3 or /4 (GE or GF) for epoxy, /10 (GI) for polyimide and /6, /7, /8, or /9 (GP, GR, GT, or GX) for polytetrafluoroethylene.

3I607 QUALIFICATION INSPECTION

Qualification inspection shall consist of the examinations and tests specified in Table 6-2.

3I608 EXTENT OF QUALIFICATION

Qualification for Type 3 boards, epoxy or polyimide, shall be extended to cover Type 1 and Type 2 boards of the same material.

3I609 FAILURES

One failure shall be sufficient cause for refusal to grant qualification approval.

3I610 REVOCATION OF QUALIFICATION

Revocation of qualification shall be in conformance with the requirements of 3I203

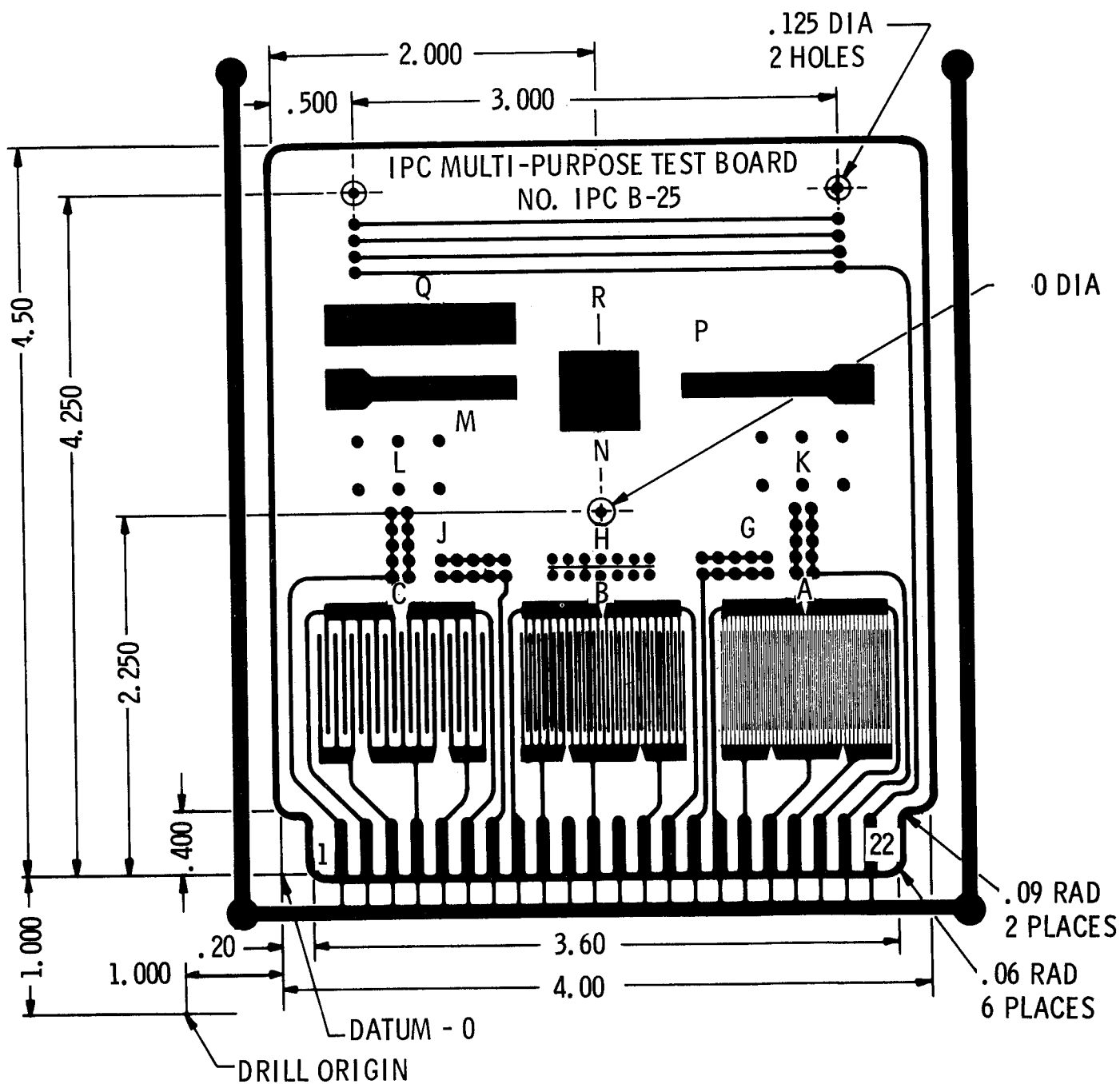
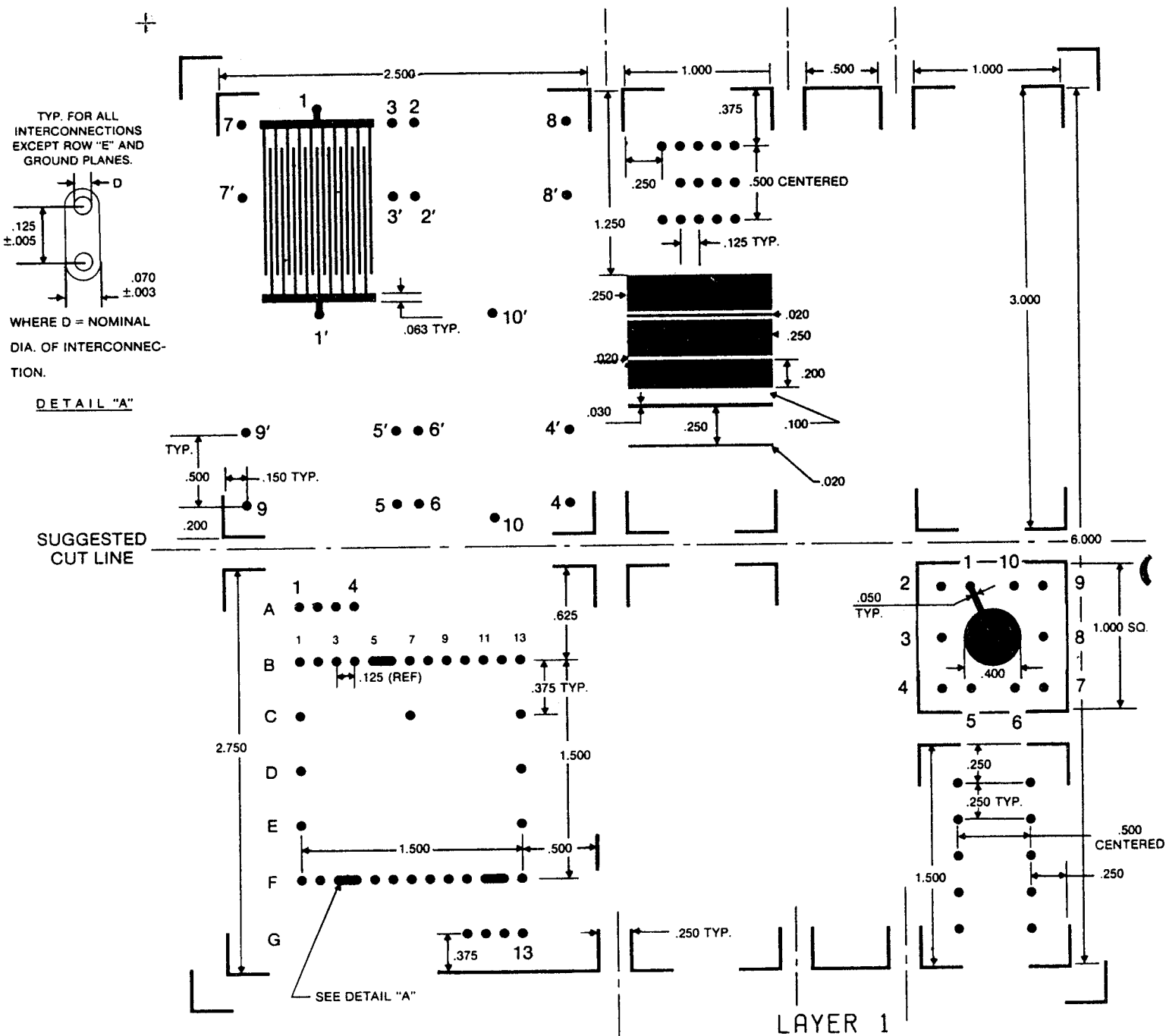


FIGURE 6-1
IPC-B-25 DOUBLE-SIDED TEST BOARD (CONTINUED ON PAGE 38)

FEATURE	PURPOSE
A	SURFACE INSULATION RESISTANCE, 6.5 MIL LINES AND SPACES
B	SURFACE INSULATION RESISTANCE, 12.5 MIL LINES AND SPACES
C	SURFACE INSULATION RESISTANCE, 25 MIL LINES AND SPACES
D	SAME AS "A" BUT ON OPPOSITE SIDE OF BOARD
E	SAME AS "B" BUT ON OPPOSITE SIDE OF BOARD
F	SAME AS "C" BUT ON OPPOSITE SIDE OF BOARD
G	INTERLAMINATE INSULATION RESISTANCE, 50 MIL HOLES, 70 MIL PADS, 100 MIL CENTERS
H	10 MIL LINE BETWEEN 60 MIL PADS ON 100 MIL CENTERS FOR SOLDER MASK
J	SAME AS "G"
K	NON PLATED THRU HOLE, BOND STRENGTH
L	PLATED THRU HOLE, BOND STRENGTH
M	PEEL STRENGTH STRIPS 150 MIL WIDE
N	500 MIL SQUARE METAL SURFACE FOR SOLDER MASK
P	OPEN DIELECTRIC AREA FOR SOLDER MASK
Q	250 MIL WIDE METAL SURFACE FOR SOLDER MASK
R	PLATED THRU HOLE CONDUCTIVITY PATTERN

FIGURE 6-1
IPC-B-25 DOUBLE-SIDED TEST BOARD (CONTINUED FROM PAGE 37)

SUGGESTED CUT LINES



INTRALAYER
INSULATION
TEST
"SPECIMEN H"

PLATING ADHESION
SHORT TO GROUND
& CROSS-SECTIONING
"SPECIMEN B"

"SPECIMEN E"

FLEXURAL STRENGTH
"SPECIMEN C"

CONTINUITY
TEST
"SPECIMEN G"

WATER ABSORPTION
"SPECIMEN D"

TEST

INTERLAYER
INSULATION
RESISTANCE
"SPECIMEN
A"

FLAMMABILITY

TERMINAL
PULL
STRENGTH
"SPECIMEN
F"

COMPOSITE PANEL TEST PATTERN LOCATIONS

NOTES:

1. BASE MATERIAL .008 THICK UNLESS OTHERWISE SPECIFIED.
2. INTERCONNECTION PLATED-THRU-HOLE DIAMETER TO BE .035/.045 INCH UNLESS OTHERWISE SPECIFIED.
3. ALL LINES AND SPACING $.020 \pm .003$ ON ALL LAYERS UNLESS OTHERWISE SPECIFIED.
4. ALL LANDS .070 INCH TOL. $= \pm .005$ (SQUARE OR ROUND).
5. ETCHED CLEARANCE HOLES IN SOLID PLANES TO BE .100 INCH.

FIGURE 6-2
IPC-B-27 MULTILAYER TEST BOARD (CONTINUED FROM PAGE 39)

TABLE 6-2
QUALIFICATION INSPECTION

Examination or Test	Reqm't Para	Method Para	Qual. Test Specimen Number	Test Coupon by Board Type			Entire Test Board
				1	2	3	
Visual and dimensional							
Workmanship	3I501	3I617	1, 2	—	—	—	X
Dimensions	3I502	3I617	1, 2	—	—	—	X
Conductor pattern and edges	3I503	3I617	1, 2	—	—	—	X
Conductor width and spacing	3I504	3I617	1, 2	—	—	—	X
Measling and crazing	3I505	3I617	1, 2	—	—	—	X
Delamination	3I506	3I617	1, 2	—	—	—	X
Conductor outgrowth	3I508	3I620	2	—	—	—	X
Bow and twist	3I509	3I623	1, 2	—	—	—	X
External annular ring	3I515-2	3I619	1, 2	—	—	—	X
	3I516-4	3I618-4	2	—	—	—	X
Marking	3I513	3I617	1, 2	—	—	—	X
Plated-through hole microsection							
Plated-through hole	3I516-1	3I618-1	2	—	J	B	—
Plating thickness	3I516-3	3I618-1	2	—	J	B	—
Etch back	3I516-2	3I618-1	2	—	J	B	—
Undercutting	3I507	3I618-1	2	—	J	B	—
Dielectric thickness	3I516-5	3I618-1	2	—	J	B	—
Layer-to-layer registration	3I516-6	3I618-3	2	—		B	—
Internal annular ring	3I516-4	3I618-4	2	—	—	B	
Plating adhesion	3I510	3I621	1, 2	N	N	B	—
Thermal stress	3I516-7	3I625	1	—	J	F	—
Hole solderability	3I516-8	3I626	1	—	J	F	—
Rework solderability	3I516-9	3I622	2	—	J	F	—
Dielectric withstanding voltage	3I511	3I624	1	B	B & J	A & H	—
Circuitry	3I516-10	3I628	2	—	—	G	—
Thermal shock	3I516-11	3I631	2	—	—	G	—
Circuitry	3I516-10	3I628	2	—	—	G	—

TABLE 6-2
QUALIFICATION INSPECTION (CONTINUED)

Examination or Test	Reqm't Para	Method Para	Qual. Test Specimen Number	Test Coupon by Board Type			Entire Test Board
				1	2	3	
Solder mask							
Cleanliness	3I512	3I629	1, 2	—	—	—	X
Visual	3I514-1, 2	3I630-1	1, 2	—	—	—	X
Dimensional	3I514-3	3I630-2	1	—	—	—	X
Abrasion resistance	3I514-4	3I630-3	1	A	A	C	—
Cure	3I514-5	3I630-4	1	M	M	B	—
Resistance to solvents and fluxes	3I514-6	3I630-5	1	B	B	D	—
Hydrolytic stability/aging	3I514-7	3I630-6	<u>1/</u>	<u>1/</u>	<u>1/</u>	<u>1/</u>	N/A
Solderability	3I514-8	3I630-7	2	G	G	F	—
Resistance to solder	3I514-9	3I630-7	2	A	A	H	—
Soldering and unsoldering	3I514-10	3I630-8	1	G	G	F	—
Moisture and insulation resistance	3I514-11	3I627	1	C	C	H	—

1/ For test specimen, use approximately 4 inch × 4 inch copper sheet or copper clad laminate, coated with solder mask and cured.

3I611 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection shall consist of material verification per 3I603 and examinations or tests on the production boards and the quality conformance test coupon area as shown in Table 6-3. Selection of test coupons for testing shall be in accordance with Table 6-3. Each Type 3 production board or panel of boards shall incorporate the quality conformance test coupon(s) as specified on the approved engineering drawing. When quality conformance test coupons are not specified on the approved engineering drawing for Type 1 or Type 2 boards, a production board may be used in lieu of the test coupon. Unless otherwise specified, quality conformance test coupons used for quality conformance inspection shall be delivered with the parts. All unused quality conformance test coupons shall be retained by the supplier for 1 year unless otherwise specified.

3I612 INSPECTION OF PRODUCT FOR DELIVERY

Inspection of product for delivery shall consist of quality conformance inspection in accordance with Table 6-3.

TABLE 6-3
QUALITY CONFORMANCE INSPECTION

Examination or Test	Reqm't Para	Method Para	Unplated Type 1 and 2		Plated Type 2		Type 3	
			Spec	Freq	Spec	Freq	Spec	Freq
Visual and dimensional								
Workmanship	3I501	3I617	Board	Sample	Board	Sample	Board	100%
Dimensions	3I502	3I617	Board	Sample	Board	Sample	Board	100%
Conductor pattern and edges	3I503	3I617	Board	Sample	Board	Sample	Board	100%
Conductor width and spacing	3I504	3I617	Board	Sample	Board	Sample	Board	100%
Measling and crazing	3I505	3I617	Board	Sample	Board	Sample	Board	100%
Delamination	3I506	3I617	Board	Sample	Board	Sample	Board	100%
Conductor outgrowth	3I508	3I620	Board	Sample	Board	Sample	Board	100%
Bow and twist	3I509	3I623	Board	Sample	Board	Sample	Board	100%
External annular ring	3I515-2	3I619	Board	Sample	Board	Sample	Board	100%
	3I516-4	3I618-4	Board	Sample	Board	Sample	Board	100%
Marking	3I513	3I617	Board	Sample	Board	Sample	Board	100%
Plated-through hole microsection								
Plated-through hole	3I516-1	3I618-1	N/A	N/A	A	Sample	A or F	<u>1/</u>
Plating thickness	3I516-3	3I618-1	N/A	N/A	A	Sample	A or F	<u>1/</u>
Etch back	3I516-2	3I618-1	N/A	N/A	A	Sample	A or F	<u>1/</u>
Undercutting	3I507	3I618-1	N/A	N/A	A	Sample	A or F	<u>1/</u>
Dielectric thickness	3I516-5	3I618-1	N/A	N/A	A	Sample	A or F	<u>1/</u>
Layer-to-layer registration	3I516-6	3I618-3	N/A	N/A	A	Sample	A or F	<u>1/</u>
Internal annular ring	3I516-4	3I618-4	N/A	N/A	A	Sample	A or F	<u>1/</u>
Plating adhesion	3I510	3I621	Board	Sample	Board	Sample	Board	100%
Thermal stress	3I516-7	3I625	N/A	N/A	A	Sample	B	<u>1/</u>
Hole solderability	3I516-8	3I626	N/A	N/A	A	Sample	B	<u>1/</u>
Circuitry	3I516-10	3I628	N/A	N/A	N/A	N/A	Board	100%
Solder mask								
Cleanliness	3I512	3I629	Board	Sample	Board	Sample	Board	100%
Visual	3I514-1, 2	3I630-1	Board	Sample	Board	Sample	Board	100%
Dimensional	3I514-3	3I630-2	Board	Sample	Board	Sample	Board	100%
Resistance to solvent and fluxes	3I514-6	3I630-5	C	Sample	C	Sample	C	100%
Solderability	3I514-8	3I630-7	A	Sample	A	Sample	A or B	100%
Resistance to solder	3I514-9	3I630-7	C	Sample	C	Sample	C	100%

1/ One coupon per panel shall be tested and microsectioned for Type 3 boards.

3I613 INSPECTION LOT

An inspection lot shall consist of all boards fabricated from the same materials, using the same processing procedures, produced under the same conditions in one tank load in a batch plating operation or in one shift's production in an automated line, and offered for inspection at one time.

3I614 SAMPLING PLAN

All Type 3 (multilayer) boards shall be inspected 100 percent. Sampling for Types 1 and 2 shall be by Lot Tolerance Percent Defective (LTPD) plans (as included in Appendix B of MIL-M-38510) with an LTPD of 10 for Type 2 boards with plated-through holes and 15 for Types 1 and 2 with unplated holes. Table 6-5 represents an updating of Table B II from MIL-M-38510 for lot sizes up to 200 pieces. Table 6-4 includes the appropriate columns of Table B I, from MIL-M-38510, for lots of over 200.

1. **Sample Size.** The sample size shall be determined from Table 6-4 or 6-5, and shall meet the specified LTPD. The manufacturer may select a sample size greater than that required; however, the number of failures permitted shall not exceed the acceptance number associated with the chosen sample size in Table 6-4 or 6-5.

TABLE 6-4
LTPD SAMPLING PLAN FOR LOTS OVER 200

LTPD	15	10	7
Acceptance Number	Minimum Sample Sizes		
0	15	22	32
1	25	38	55
2	34	52	75
3	43	65	94
4	52	78	113
5	60	91	131
6	68	104	149
7	77	116	166
8	85	128	184
9	93	140	201
10	100	152	218

TABLE 6-5
SAMPLING PLANS FOR LOTS OF 200 OR LESS ^{1/}

Acceptance Number				0			1			2		
LTPD 15				10	7		15	10	7	15	10	7
Lot 1/ Size										Minimum Sample Size		
10	8	all	all	all	all	all	all	all	all	all	all	all
20	10	14	17	16	19	all	all	all	all	all	all	all
30	11	16	20	19	24	28	24	29	all	all	all	all
40	12	17	22	20	27	34	26	29	all	all	all	all
50	12	18	24	21	29	37	28	37	47	all	all	all
60	13	18	25	21	30	39	28	39	50	all	all	all
80	13	19	26	22	31	43	30	42	56	all	all	all
100	13	20	27	22	33	44	31	42	59	all	all	all
120	13	20	28	23	33	46	31	45	61	all	all	all
150	14	20	29	23	34	47	32	46	64	all	all	all
160	14	20	29	23	34	48	32	47	64	all	all	all
200	14	21	29	23	35	49	32	48	66	all	all	all

^{1/} The lot size row which is nearest in value to the actual size of the submitted lot shall be used, except that if the actual lot size is midway between two of the lot sizes given in the table, either of the bounding lot size rows may be used at the manufacturer's option.

2. **Failure.** Failure of a part for one or more attributes shall be charged as a single failure.

3. **Acceptance Procedures**

- (a) Select an acceptance number. An acceptance number is defined as an integral number which determines the maximum number of defectives permitted. It is recommended that acceptance numbers greater than zero normally be chosen unless extremely high confidence exists in the quality of the samples.

- (b) From Tables 6-4 or 6-5, determine the sample size specified for the lot size, required LTPD, and preselected acceptance number.
 - (c) Perform required testing. If the observed number of defectives from the first sample is less than or equal to the preselected acceptance number, the lot shall be accepted. If the observed number of defectives exceeds the preselected acceptance number, an additional sample may be chosen such that the total sample complies with 3I614-4.
4. **Additional Sample.** The manufacturer may add an additional quantity to the initial sample, but this may be done only once for any lot and the added samples shall be subjected to all the tests specified. The total sample size (initial and added samples) shall be determined by a new acceptance number selected from Table 6-4 or 6-5. The table which is used for the first sampling of a given inspection lot for a given subgroup shall be used for any or all subsequent sampling for the same lot and subgroup for each lot submission.

3I615 REJECTION LOTS

If an inspection lot is rejected, the supplier may screen out the defective units and resubmit. Resubmitted lots shall be inspected using next lower LTPD number. Such lots shall be kept separate from new lots, and shall be clearly identified as reinspected lots.

3I616 INSPECTION OF PACKAGING

Except when commercial packaging is specified in accordance with MIL-STD-1188, the sampling and inspection of the preservation packaging and interior package marking shall be in accordance with the Groups A and B quality conformance inspection requirements of MIL-P-116. The sampling and inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129. The inspection of commercial packaging shall be as specified by the procuring NASA agency.

3I617 VISUAL AND DIMENSIONAL EXAMINATION

The boards shall be examined to verify that the construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3I501 through 3I506; 3I512; 3I513; 3I515-1 and -2; and 3I516-1 through -6) and the approved engineering drawing. Features of the boards shall be measured at 3X magnification. Referee magnification for board features, plated-through hole quality, and plating thickness shall be as required.

3I618 PLATED-THROUGH HOLE EXAMINATION

1. **Vertical.** Plated-through holes shall be microsectioned in the vertical plane at the center of the hole and examined for quality of plating at a magnification of $100X \pm 5$ percent. Plating thickness shall be measured at a magnification of $200X$ minimum. Each side of the hole shall be viewed independently. A minimum of one microsection containing at least three holes shall be made for each sample tested. Examination shall be made both before and after the specimen is etched.
2. **Measurement Point.** Measurements shall be taken at the thinnest point in the hole wall plating.
3. **Layer-to-Layer Registration.** (See 3I516-6.) Layer-to-layer registration (see Figure 6-3) shall be measured at 50 to 100 magnifications after vertical microsectioning as detailed in 3I618-1. The microsection shall be evaluated by computing the difference of centerlines of terminal areas shifted to extreme positions. If referee measurement is required, a second microsection shall be made in a direction perpendicular to the first.

After laminating and drilling, multilayer boards may be X-ray examined to assure that the drilled holes pass through the pads on each layer leaving sufficient copper around the holes to meet the requirements of 3I516-4 for minimum annular ring and that the registration meets the requirements of 3I516-6. In event of conflict between X-ray and microsection, the microsection shall govern.

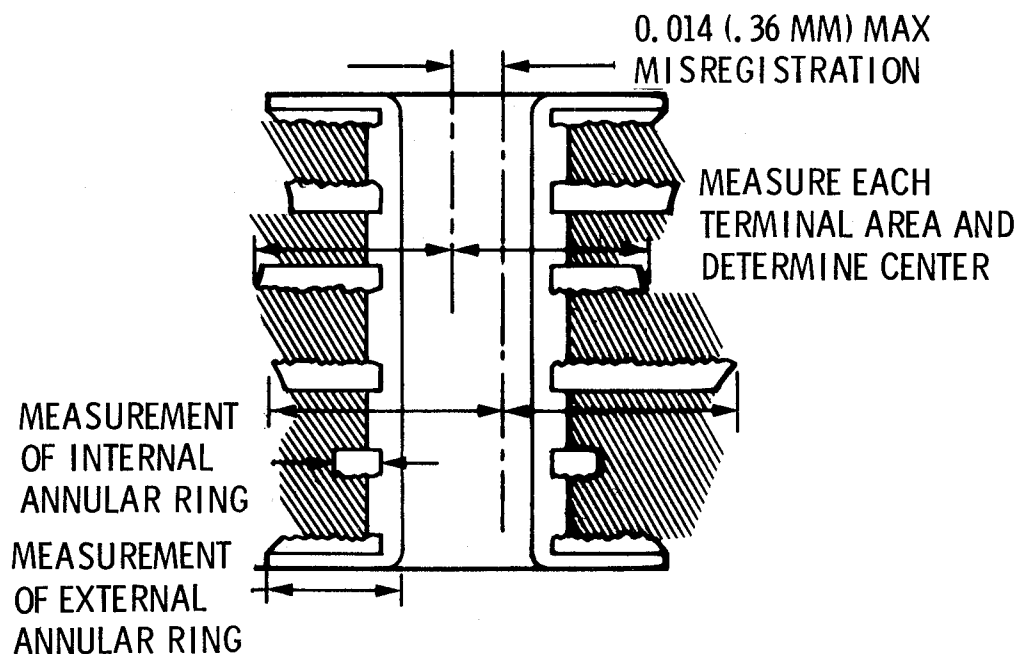


FIGURE 6-3
LAYER-TO-LAYER REGISTRATION AND ANNULAR
RING MEASUREMENT

4. **Annular Ring Measurement (Types 2 and 3; See 3I516-4).** The measurement of the annular ring on external layers shall be from the inside surface (within the hole) of the plated hole to the outer edge of the annular ring on the surface of the board. On internal layers, the annular ring shall be measured from the edge of the drilled hole to the outer edge of the annular ring.

3I619 ANNULAR RING MEASUREMENT (TYPES 1 AND 2 UNPLATED)

The annular ring on Type 1 and Type 2 boards without plated-through holes shall be measured from the edge of the drilled hole to the outer edge of the annular ring (see 3I515-2 and Figure 5-2).

3I620 CONDUCTOR EDGE OUTGROWTH

The extent of outgrowth on conductors shall be determined by measuring the conductor width before and after mechanical removal of the metal outgrowth (see 3I508). If a referee test is required, the conductor shall be crosssectioned. The procedure for removing the outgrowth in this test shall be as follows:

1. Wet the board in tap water at room temperature.
2. Brush the wet board with a brass wire brush to remove the metal outgrowth. Use moderate pressure and brush in the direction of the conductor trace.

3I621 PLATING AND SOLDER ADHESION

A strip of pressure-sensitive cellulose tape conforming to Type 2, Class A of L-T-90, 0.5 inch (12.7 mm) wide and 2 inches (51 mm) long, shall be placed across the surface of the conductor pattern and pressed firmly onto the conductors to eliminate air bubbles. A tab shall be left for pulling. The tape shall be pulled with a snap pull at an angle of approximately 90° to the board. Tape shall be applied to and removed from three different locations on each board tested. When edge board contacts are part of pattern, at least one pull must be on the contacts. Fresh tape shall be used for each pull. If the metal outgrowth breaks off (slivers) and adheres to the tape, this is evidence of outgrowth (see 3I508) but not plating adhesion failure (see 3I510).

3I622 REWORK SOLDERABILITY (PLATED-THROUGH HOLES)

Three holes per coupon shall be tested. Insert wires in holes in selected terminal areas and solder to terminal areas by machine or hand, as applicable. The diameter of the inserted wire lead shall be smaller than the hole, such that the difference between the inside diameter of the plated-through hole and the nominal outside diameter of the lead shall be not greater than .028 in. (.71 mm) or less than .010 in. (.25 mm). The wires shall not be clinched. Subject the wires to five cycles of unsoldering and soldering by hand after the initial machine or hand soldering. During the five cycles the wires shall be completely removed during each unsoldering operation and replaced during each soldering operation. A conventional soldering iron operating at a reduced voltage sufficient to produce a tip temperature of 450°-500°F (232°-260°C) shall be used for the unsoldering and soldering operation. The iron shall be applied to the leads, not the foil, and shall be applied only as long as is necessary to perform the unsoldering or soldering operation. After testing, the holes shall be microsectioned and examined to assure that they meet the requirements of 3I516-7 and 3I516-8.

3I623 BOW AND TWIST (TYPES 1,2, AND 3)

The panel shall be placed unrestrained on a flat horizontal surface with the convex surface of the panel upward. The maximum vertical displacement (the vertical distance from the horizontal surface to the maximum height of the concave surface) shall then be determined by taking the measurement and subtracting the thickness of the board if it is included in the height measurement. The adjusted height divided by the length of the longest side and multiplied by 100 shall be considered the percent bow (see 3I509). Twist is measured similarly, except the measurement is made diagonally (corner to corner).

3I624 DIELECTRIC WITHSTANDING VOLTAGE

Specified quality conformance test circuits shall be tested with a potential of 1,000 volts dc for a period of 30 seconds in accordance with Method 301 of MIL-STD-202. The dielectric withstanding voltage shall be applied between all common portions of each test pattern and all adjacent common portions of each test pattern (see 3I511). The voltage shall be applied between conductor patterns of each layer and the electrically isolated pattern of each adjacent layer.

***3I625 THERMAL STRESS (SOLDER FLOAT)**

Specimens shall be conditioned at 250° to 300°F (121°-149°C) for a period of 2 hours minimum to remove the moisture. After conditioning, cool specimens on a ceramic plate in a desiccator. The specimens shall then be fluxed (Type RMA of MIL-F-14256) and floated in a solder bath [Sn 63 ± 5 percent, maintained at 550° ± 10°F (288 ± 6°C)] for a period of 10 seconds. Solder temperature shall be measured at a probe depth not to exceed 1 inch below the molten surface of the solder. After stressing place the specimens on a piece of insulator to cool, then microsection and examine to the requirements of 3I516-7.

3I626 HOLE SOLDERABILITY

The microsectioned specimen used in 3I625 shall be examined in accordance with 3I516-8.

3I627 MOISTURE AND INSULATION RESISTANCE

The moisture and insulation resistance test shall be performed in accordance with MIL-STD-202, Method 106, using only the first six steps for ten cycles with applied polarization voltages and Method 302, Test Condition A of MIL-STD-202. A 100-volt dc polarizing voltage shall be applied during chamber exposure. Final measurements shall be made at room temperature within 2 hours after removal from the test chamber (see 3I514-11).

3I628 CIRCUITRY

1. **Short Testing.** A test voltage shall be applied between all common portions of each conductor pattern and all adjacent common portions of each conductor pattern. The voltage shall be applied between conductor patterns of each layer and the electrically isolated pattern of each adjacent layer.

The minimum applied breakdown test voltage shall be 60 volts dc unless otherwise specified on the approved engineering drawing.

2. **Continuity Testing.** A current shall be passed through each conductor or group of interconnected conductors by applying electrodes on the terminals at each end of the conductor or group of conductors. The current passed through the conductors shall not exceed that specified on the master drawing for the smallest conductor in the circuit.

3I629 CLEANLINESS AND RESISTIVITY OF SOLVENT EXTRACT

A funnel of requisite size shall be positioned over an electrolytic beaker. The printed wiring board shall be suspended within the funnel. A wash solution of 75 percent by volume of American Chemical Society (ACS) reagent grade isopropyl alcohol and 25 percent by volume of distilled water shall be prepared. This wash solution shall have a resistivity equal to or greater than 6×10^6 ohm-centimeters. The wash solution shall be directed in a fine stream from a wash bottle onto both sides of the printed wiring board until 100 milliliters of the wash solution are collected for each 10 square inches of board surface (taking into account both sides of the board). The time required for the wash shall be a minimum of 1 minute. The initial washings shall be included in the sample to be measured for resistivity. The resistivity of the collected wash solution shall be measured with a conductivity bridge or another instrument of equivalent range and accuracy. (See 3I512.)

NOTE: The following methods of determining the cleanliness of printed wiring boards have been shown to be equivalent to the resistivity of the solvent extract method.

- a. The Kenco Alloy and Chemical Company, Incorporated, "Omega Meter™, Model 200."
- b. Alpha Metals Incorporated, "Ionograph™."
- c. E.I. Dupont Company, Incorporated, "Ion Chaser™."

Test procedures and calibration techniques for these methods are documented in Materials Research Report 3-78, Review of Data Generated with Instruments Used to Detect and Measure Ionic Contaminants on Printed Wiring Assemblies. Application for copies of this report should be addressed to the Commander, Naval Avionics Center, Indianapolis, IN 46219. Table 6-6 lists the equivalence factors for these methods in terms of microgram equivalents of sodium chloride per unit area.

TABLE 6-6
EQUIVALENCE FACTORS

Method	Ohm-Cm ($\times 10^6$)	Equivalence Factor	Equivalent of Sodium Chloride	
			Micrograms per Sq. In.	Micrograms per Sq. Cm.
Resistivity of solvent extract	2	1	7.545	1.17
Omega Meter™	2	1.39	10.51	1.63
Ionograph™	2	2.01	15.20	2.36
Ion Chaser™	2	3.25	24.50	3.80

3I630 SOLDER MASK (SEE 3I514)

1. **Appearance.** Appearance shall be observed visually with the aid of a 3 to 10 power magnification viewer. The coating material shall be examined for evidence of foreign material, inclusions, peeling, and roughness.
2. **Coating Thickness.** The coating thickness shall be measured by a micrometer or indicator accurate to 0.0003 inch (0.008 mm).
3. **Abrasion.** The abrasion resistance of the cured solder mask shall be determined using the pencil method in accordance with Test Method 2.4.27.2 of IPC-TM-650.
4. **Cure.** The permanency of solder mask cure shall be determined in accordance with Test Method 2.3.23 of IPC-TM-650.
5. **Resistance to Solvents and Fluxes.** Unless otherwise specified, the resistance to solvents of the cured solder mask shall be determined by immersing the specimen for 2 minutes in the solvents listed in Table 6-7. After immersion, hang to dry for 10 minutes at laboratory conditions and examine for surface degradation, such as roughness, blisters, delamination, swelling, and color change.

When required, the resistance of the cured solder mask to fluxes shall be determined by immersing the specimen for 2 minutes in the flux specified in the procurement document, after completion of the solvent resistance test specified above. After immersion, clean with the solvent specified in the procurement document and examine for surface degradation, including tackiness.

TABLE 6-7
RESISTANCE TO SOLVENTS

Solvent	Test Conditions
Isopropanol	Standard laboratory
1,1,1 Trichloroethane	Standard laboratory
Trichlorotrifluoroethane	Vapor degreaser
Azeotrope of 4 percent ethyl alcohol and 96 percent trichlorotrifluoroethane	Vapor degreaser
1,1,1 Trichloroethane	Vapor degreaser
Alkaline detergent (e.g., 3 percent trisodiumphosphate and water)	140 °F

The resistance to fluxes of the cured solder mask also shall be determined by the test specified in item 7, when required, using the appropriate flux and cleanser specified in the procurement document. After cleaning, re-examine per requirements stated above.

6. **Hydrolytic Stability/Aging.** The hydrolytic stability and aging of the cured solder mask shall be determined by exposing the specimen to 95 percent relative humidity at a temperature of 212 °F (100 °C) for a period of 7 days and examining the appearance and surface tackiness in accordance with the ambient temperature insulation resistance measurement requirements of Test Method 2.3.23 of IPC-TM-650.

Tackiness shall be determined by touching the surface of the specimen with a swab of absorbent cotton and inspecting for particles of cotton adhering to the material.

Reversion shall be determined by visual examination and in accordance with the detailed requirements of Test Method 2.6.11 of IPC-TM-650.

7. **Solderability and Resistance to Solder.** The solderability of the printed board and the solder resistance of the cured solder mask shall be determined by coating the specimen with type RMA flux per MIL-F-14256, holding at ambient temperature for 5 minutes, and exposing to a solder float (Sn60 or Sn63 solder per QQ-S-571) at 490 °F \pm 10 °F (254 ° \pm 6 °C) for 10 seconds. Immediately thereafter, visually inspect at 10X magnification for acceptance of solder on the uncoated areas and for the resistance of the solder mask to accept solder.
8. **Soldering and Unsoldering.** The ability of the cured solder mask to withstand soldering and unsoldering shall be determined by subjecting the specimen to the following:
 - (1) Clean the test area using standard procedures and cleaning materials.
 - (2) Apply flux conforming with MIL-F-14256, type RMA.
 - (3) Solder and unsolder a pretinned lead wire of suitable diameter five times, using solder conforming with QQ-S-571. (Apply the heat source only to the wire.) Allow sufficient cooling time between operations. Soldering shall be performed by trained personnel using standard industry tools. Visually inspect at 2-4X magnification.

3I631 THERMAL SHOCK

The specimens shall be tested for 100 cycles in accordance with the following test schedule:

<u>Low temp</u> <u>°C + 0 - 5</u>	<u>Time</u> <u>Min. + 2 - 0</u>	<u>High temp</u> <u>°C + 5 - 0</u>	<u>Time</u> <u>Min. + 2 - 0</u>	<u>Type</u>
- 65	15	125	15	GE, GF
- 65	15	150	15	GP, GT, GX, GR
- 65	15	204	15	G I

Transfer time between chambers shall be less than 2 minutes. The thermal capacity of the chambers used shall be such that the ambient temperature shall reach the specified temperature within 2 minutes after the specimen has been transferred to the appropriate chamber. A circuitry test in accordance with 3I628 shall be performed after completion of the 100 thermal cycles. After testing, microsection and examine in accordance with 3I618.

APPENDIX A

DEFINITIONS

The following definitions apply to terms used in printed wiring board fabrication:

Adhesion. The attractive force that exists between a coating material and its substrate that can be measured as a force required to separate the coating material and its substrate.

Annular Ring. An annular ring is the portion of conductive material completely surrounding a hole.

B-Stage. B-stage is an intermediate state of cure of a thermosetting resin.

Blister. A blister is a localized swelling and separation between any of the layers of a laminated base material, or between base material and conductive foil.

Bonding Layer. A bonding layer is an adhesive layer used in bonding together other discrete layers of a multilayer printed board during lamination.

Bow (Base Material). Bow is the deviation from flatness of a board characterized by a roughly cylindrical or spherical curvature such that, if the board is rectangular, its corners or edges are in the same plane as the major surfaces of the board (see Figure A-1).

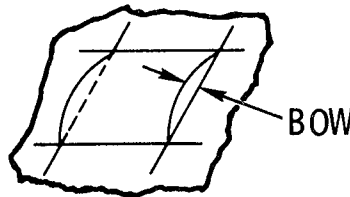


FIGURE A-1
BOW (BASE MATERIAL)

Clad or Cladding. Clad or cladding is a relatively thin layer or sheet of metal foil which is bonded to the base material.

Crazing (Base Material). Crazing is an internal condition occurring in the laminated base material in the form of connected white spots or crosses (measling). It is usually made visible by mechanical or thermal stresses or both. This connected measling forms continuous paths which may carry moisture or electric current or both.

Delamination. Delamination is a separation between plies within the base laminate, between any of the layers of the base laminate and B-stage material, or between the laminate and the metal cladding.

Dewetting. Dewetting is a condition which results when the molten solder has coated the surface and then receded, leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film; the base material is not exposed. (See Figure A-2.)

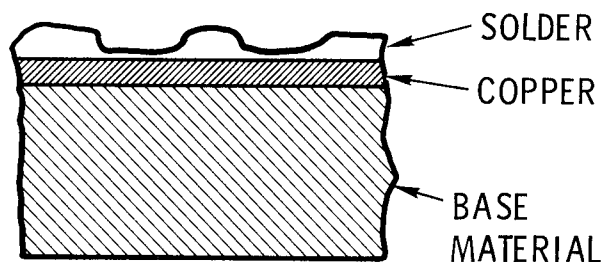


FIGURE A-2
DEWETTING

Dielectric Withstanding Voltage Tests. Dielectric withstanding voltage tests are tests made to determine the ability of insulating materials and spacings to withstand specified overvoltage for a specific time without flashover or puncture.

Etchback. Etchback is the chemical process of removing glass fibers and resin between the conductor layers, in order to facilitate a mechanical and electrical bond on the protruding portion of the conductor materials in the plated-through holes.

Flux. Flux is a chemically active compound that facilitates the wetting of metals with solder.

Insulation Resistance. Insulation resistance is the electrical resistance of the insulating material between any pair of contacts, conductors, or grounding devices in various combinations.

Laminate. Laminate is the product made by bonding together two or more layers of material using an adhesive with heat and pressure.

Mask. A mask is a coating material/resist used to mask or protect selected areas of a pattern from the action of an etchant, solder, or plating.

Measling. Measling is an internal condition occurring in the laminated base material in which the glass fibers are separated from the resin. This condition exists in the form of discrete white spots or crosses evident at individual and scattered weave intersections. It is usually made visible by mechanical or thermal stresses or both.

Moisture Resistance. Moisture resistance is the ability of a material to resist absorbing ambient moisture.

Outgrowth. The increase in conductor width at one side of a conductor, caused by plating build-up, over that delineated on the production master. (See Figures A-3 and A-4.)

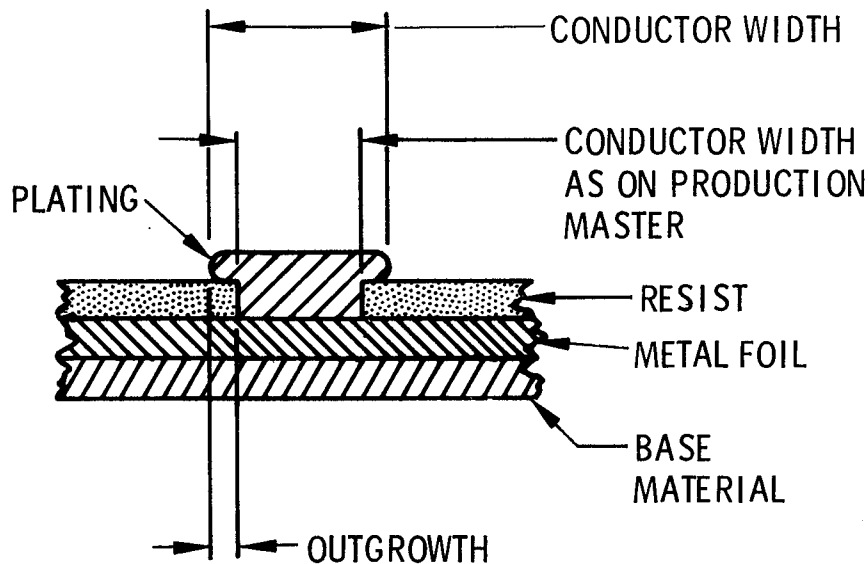


FIGURE A-3
OUTGROWTH

Overhang. The sum of outgrowth and undercut (see Figure A-4). (If undercut does not occur, the overhang is the outgrowth only.)

PWB. Printed wiring board.

Plated-Through Hole. A plated-through hole is an interfacial connection formed by the deposition of conductive material on the sides of a hole through the base material.

Plating Void. Plating void is the area where metal plating is missing from a specific cross sectional area.

Repair. Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes rather than reprocessing are employed.

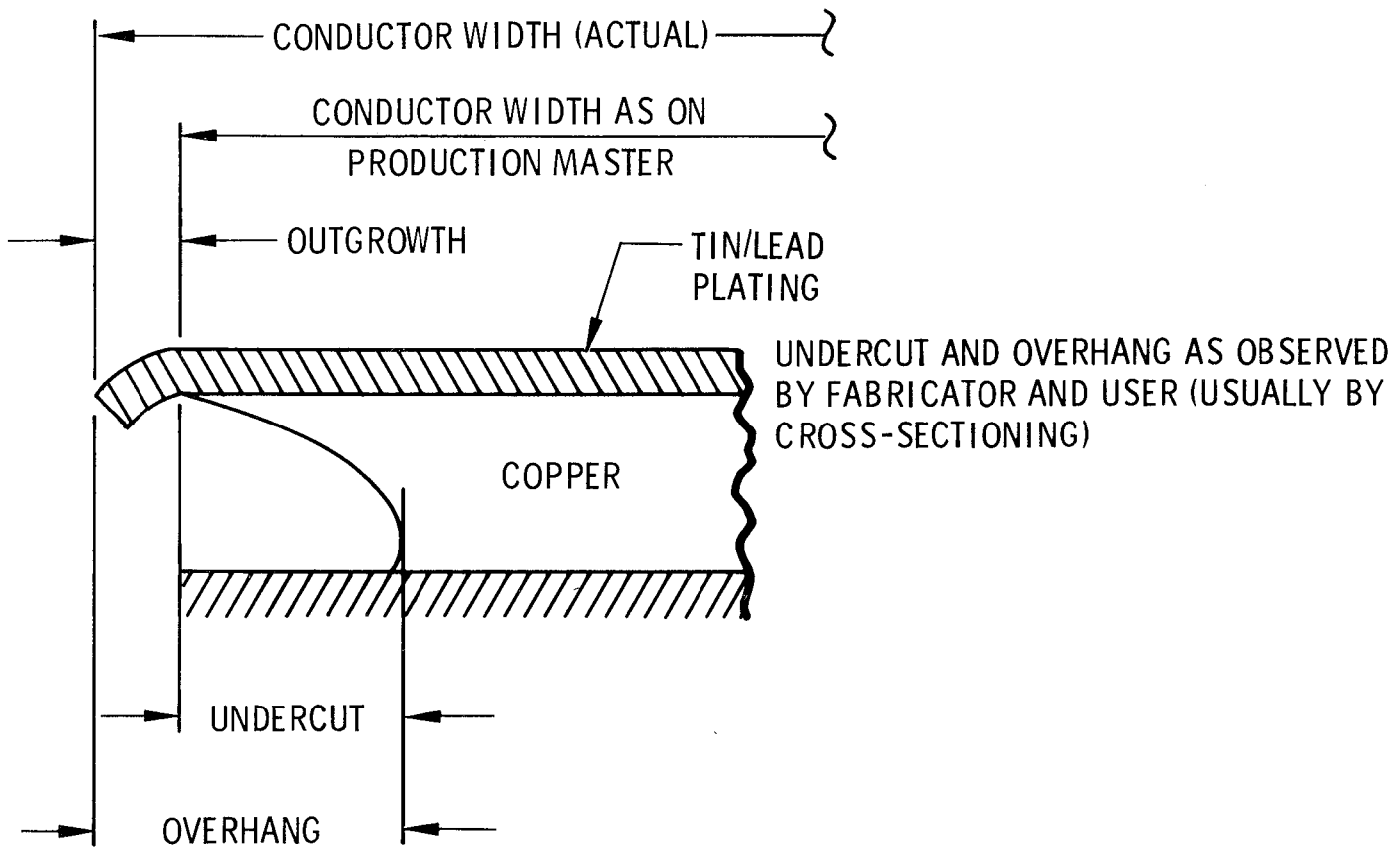


FIGURE A-4
OVERHANG AND UNDERCUT

Rework. The reprocessing of articles or material that will make it conform to drawings, specifications, or contract.

Solderability. Solderability is the property of a metal to be wet by solder.

Test Coupon (Quality Conformance Test Coupon). A portion of a printed board or panel containing printed coupons, used to determine the acceptability of such a board(s).

Thermal-Shock Test. The thermal-shock test is used to determine the ability of a printed wiring board to withstand repeated temperature cycling without losing electrical continuity and current-carrying capacity, and without degradation of the materials.

Thermal-Stress Test. The thermal-stress test is used to determine the ability of a printed wiring board to withstand the soldering operation without fracturing the plated-through holes or other conductors and without degradation of the materials. It consists of floating the specimens on molten solder followed by microsectioning the plated-through holes and visually examining the board and the microsectioned holes.

Undercut. The distance on one edge of a conductor measured parallel to the board surface from the outer edge of the conductor, excluding overplating and coatings, to the maximum point of indentation on the same edge. (See Figure A-4.)

Warp (Fabric). The warp consists of the threads of the reinforcing glass fabric that run in machine or rolled direction of the basic roll of glass fabric when woven or processed. The resulting laminated base material is usually stronger in the warp direction than in the fill direction.

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APPENDIX B

PROCEDURE FOR METALLOGRAPHIC PREPARATION AND EXAMINATION OF PRINTED WIRING BOARD TEST HOLE COUPONS

Note 1: The accuracy and reliability of this method are highly dependent on individual technique and skill. Experienced personnel and a microscope of good quality are prerequisites to accurate evaluation.

Note 2: In addition to the specific procedure listed herein, reference is also made to ASTM Method E2, "Preparation of Micrographs of Metals and Alloys," ASTM Method E3, "Preparation of Metallographic Specimens," and ASTM Method B487, "Measurement of Metal and Oxide Thicknesses by Microscopical Examination of a Cross Section."

Description of Specimen:

Cut specimen from test coupon so that it contains at least three holes of the smallest size used for component leads. Holes should have pads at each layer. For additional evaluation specimens may be cut parallel to the surface. For examination after thermal stress, test coupons must have been solder float tested prior to microsectioning. For plated-through hole examination, test coupons must have been subjected to all normal manufacturing steps, including solder reflow when specified.

Test Equipment / Apparatus:

Glass plate 5 in. × 7 in. or aluminum weighing dishes approximately 2-1/2 in. diameter.
Aluminum or Bakelite rings 1 in. or 1-1/4 in. diameter.
Silicone release agent.
Room-temperature curing potting material.
Wooden spatulas.
Plastic cups.
Saw or shear.
Engraver.
240 grit abrasive.
Double coated tape or stainless steel spring clips.
Metallographic polishing table.
240, 320, 400 and 600 grit abrasive papers.
1.0, 0.3 and 0.05 micron alumina slurries (Nos. 1, 2, and 3 liquid alumina polish).
Polishing cloths.
Chemical etchants.

NOTE: SPECIMEN ENCAPSULATION PROCEDURES INVOLVING TEMPERATURES IN EXCESS OF 100°C OR PRESSURE MOLDING APPARATUS SHOULD BE AVOIDED.

For Metallographic Evaluation:

Metallurgical microscope with camera accessories.
Filar eyepiece or graduated reticle.

Procedure for Encapsulation:

1. Clean glass plate and rings and dry thoroughly. If using aluminum weighing dishes, no cleaning is necessary. Use one dish for each ring.
2. Apply strip of double-coated tape to plate to support specimen if spring clips are not used. Apply thin film of release agent to glass plate or dish (and ring if desired) and place ring on plate or dish.
3. Sand the long edge of the perpendicular specimen until the edges on the conductor pads appear and the specimen will stand on edge on a flat surface. Use 240 grit abrasive.
4. When secondary plating thickness is being measured, overplate specimen with a harder electroplated metal. Specimens may be overplated as per ASTM Method E 3-58T.
5. Stand specimen on edge on double-coated tape or insert into spring clip with the plated-through hole edge down. Avoid covering holes with clip. For parallel specimens omit the tape or clip and lay specimen flat on glass plate inside spring.
6. Mix potting material and pour to one side of the specimen until it flows through the holes. Support the specimen in vertical position if necessary. Continue pouring until ring is full. Avoid entrapment of air.
7. Allow specimen to cure at room temperature. Accelerated curing at elevated temperature is permissible following manufacturer's instructions, provided the temperature does not exceed 100 °C and provided cracking and distortion do not occur.
8. Identify specimen promptly by engraving.
9. If more than one specimen is potted in one ring, the specimens should be spaced apart to facilitate filling the holes. Adequate care should be taken to identify each specimen.

Grinding and Polishing:

1. Rough grind face of specimen to the approximate center of the plated-through holes using 240, 320, 400 and 600 grit papers in that order. Do not omit any steps. When changing grit size, rotate the specimen 90 degrees and grind on the finer grit for at least twice the length of time it takes to remove the scratches caused by the coarser grit. Rinse specimen in tap water between steps.
2. Flush away all residue using tap water at room temperature. Wash hands to avoid carrying over coarse grits.
3. Rough polish using a slurry of 1.0 micron alumina (#1) in distilled water on a nylon cloth until all scratches from the 600 grit are removed. Follow with 0.3 micron (#2) alumina slurry on another nylon 0.05 micron (#3) alumina slurry on a napped cloth. Rinse hands and specimen thoroughly between steps.
4. Rotate the specimen 360 degrees about the axis of the wheel and opposite the direction of rotation of the wheel, keeping the face of the specimen flat on the wheel.
5. Rinse in warm tap water and/or alcohol and dry in warm forced air.
6. Examine multilayer board innerplane-to-barrel plating interfaces before any chemical etching.
7. Chemically etch the specimen to reveal plating microstructure. A 1:1 solution by volume of concentrated ammonium hydroxide and 3 percent hydrogen peroxide will etch copper but not attack tin-lead solder. Solution must be freshly prepared and may be applied by swabbing gently for about 8-10 seconds. Rinse well with warm water or alcohol and dry with warm forced air.

Microscopic Examination:

1. Multilayer boards shall be examined prior to chemical etching at a magnification of 200X for evidence of cracks, separations, resin smear or oxide films at the innerplane-barrel junctions.
2. Plating microstructure and thickness shall be evaluated after etching at a magnification of 100X minimum.
3. Other microscopic examinations to be performed as required.

APPENDIX C

IPC TEST METHODS FOR SOLDER MASK EVALUATION

TEST METHODS MANUAL

NOTE: *Material in this Test Methods Manual was voluntarily established by Technical Committees of the IPC. This material is advisory only and its use or adaptation is entirely voluntary. IPC disclaims all liability of any kind as to the use, application, or adaptation of this material. Users are also wholly responsible for protecting themselves against all claims or liabilities for patent infringements.*

Number: 2.3.23

Subject: Solder Mask Cure (Permanency) Thermally Cured Masks

Date: 8/77

1. SCOPE

This test method covers the cure, or permanence, testing of thermally cured solder mask (solder resist) organic coatings. Solder masking is the application of either a liquid film or dry film coating on all types of laminates and circuits. The coating is where no solder is to appear and conversely is omitted where soldering is intended.

2. TEST SPECIMENS

Any sample preproduction board with the solder mask coating applied and cured as recommended by the manufacturer.

3. APPARATUS

- 3.1 Reagent grade methylene chloride.
- 3.2 Petrie dishes.
- 3.3 Lint free cloths.
- 3.4 Stop watch.

4. PROCEDURE

- 4.1 Prepare specimens as described by the manufacturer or as described below. Apply the solder mask to the clean test specimen surface and cure for 1 hour \pm 10 minutes. When a batch type chamber is used, it is essential to have a good exhaust to remove the evaporating solvent vapors. After curing, clean the surfaces, rinse, dry, and seal with manufacturer's recommended sealant.

- 4.2 Place several drops of methylene chloride on separate locations on the surface of the solder mask and allow to stand for 1 minute.
- 4.3 Attempt to wipe off the solder mask using a lint free cloth.
- 4.4 Scratch the surface with the fingernail to determine permanence.
- 4.5 If no attack is observed, the solder mask has sufficient permanency.

5. NOTES

- 5.1 These test methods do not adequately predict the ability of the solder mask to withstand hot solvent vapors, such as degreasers. Any chemicals used in the production of circuit boards may be applied as described in paragraph 4.1 and the samples evaluated.
 - 5.1.1 The insulation resistance of the solder mask is critical since it becomes a permanent part of the circuit board. Performance of an occasional electrical resistance test is also recommended because this result is dependent on the degree of cure. The more complete the cure, the higher the resistance.

Number: 2.4.27.2

Subject: Solder Mask Abrasion (Pencil Method)

Date: 8/77

1. SCOPE

This method is designed to evaluate the hardness of solder masked surfaces and its resistance to abrasion.

2. APPLICABLE DOCUMENTS

ASTM D3363-74 Film Hardness by Pencil Test.

3. TEST SPECIMEN

IPC Multipurpose Test Board, IPC-B-25, or any preproduction or production board coated with solder masking.

4. APPARATUS

Standard set of hardness pencils.

5. PROCEDURE

Place the test board on a firm horizontal surface. Starting with the hardest pencil, hold pencil firmly against the solder mask at a 45 degree angle. Push pencil away from the operator with uniform downward and forward pressure in a 1/4 inch stroke. Proceed with the next hardest pencil in succession until a pencil is used which will not cut into or gouge the solder mask.

6. EVALUATION

Record the value of the hardest pencil which will neither cut into nor gouge the solder mask.

7. NOTES

Standard set of hardness pencils available from Gardner Laboratories, Inc., P.O. Box 5728, Bethesda, MD 20014, or equivalent.

Number: 2.6.11

Subject: Hydrolytic Stability Solder Mask

Date: 8/77

1. SCOPE

This test method is to determine the resistance of the applied solder mask coating to reverting to liquid when exposed to high humidity and at a specific temperature and time conditions for each class. This test method is to evaluate the quality of the solder mask coating printed boards under storage conditions (nonoperating).

2. APPLICABLE DOCUMENTS

None.

3. TEST SPECIMENS

3.1 IPC Multipurpose Test Board No. IPC-B-25, Rigid or Flexible.

3.2 Any preproduction or production sample agreed on between the contractor and the customer.

4. APPARATUS

4.1 Reagent grade potassium sulfate.

4.2 Desiccator, 10 in. diameter minimum.

4.3 Cotton swabs.

4.4 Test chamber (oven) capable of maintaining up to 100 °C ($\pm 1^\circ$).

5. PROCEDURE

5.1 Preparation

5.1.1 Prepare a saturated solution of distilled water and potassium sulfate (15 grams per 100 cc) at temperature of test as indicated in paragraph 5.1.4. Pour into desiccator to a level just below the ceramic plate.

5.1.2 Clean test specimen thoroughly using the solder mask suppliers' recommended solutions and procedures.

5.1.3 Place test specimen flat on the surface of the ceramic plate, seal the desiccator lid with silicone grease and close desiccator.

- 5.1.4 Place desiccator in test chamber (oven) preset at the following conditions:

<i>Class</i>	<i>Temperature</i>	<i>Time</i>
1	35 ± 1 °C	96 hours
2	85 ± 2 °C	168 hours
3	100 ± 2 °C	168 hours

5.2 EVALUATION

- 5.2.1 After the required time exposure, remove test specimens and visually examine for chalking, blistering, cracking and general degradation.
- 5.2.2 Touch the surface of the solder mask coating with a swab of absorbent cotton and observe for particles of the cotton adhering to the solder mask coating.

6. NOTES

Examination and testing may be done at intervals between the test chamber time requirements, if there is suspicion of an early failure and evaluation time is critical.

